AUTOMOBILE ENGINEER

DESIGN · PRODUCTION · MATERIALS

Vol. 51 No. 2 FEBRUARY 1961 PRICE: 3s. 6d.

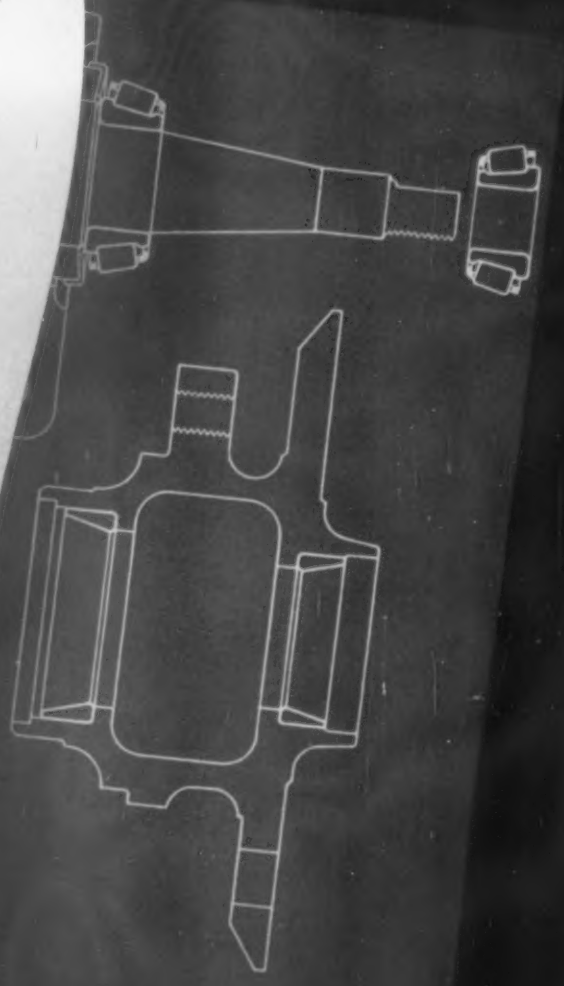
Timken bearings are unsurpassed in carrying journal and thrust loads with precision and 'rigidity'.

In addition to these functional advantages, *Timken bearings bring many others; their high load capacity permits the use of more compact bearings, saving on size of housings and other related parts.*

Being adjustable, they are not overloaded by effects of normal-tolerance variations in shaft diameter and housing bore.

Finally, since the inner assembly is freely separable from the cup, assembly and dismantling of machinery is simplified.

British Timken, Duston, Northampton, Division of The Timken Roller Bearing Company. Timken bearings manufactured in England, Australia, Brazil, Canada, France and U.S.A.



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tapered roller bearings

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LMS 25 Impact Wrench

LSS 62 Surface Grinder

MT505 Hoist

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Atlas Copco's range of equipment for the motor industry includes air-powered tools anatomically designed and balanced to speed up production and reduce operator fatigue. With their excellent power/weight ratios, these tools make an important contribution towards higher productivity.

Wherever there are nuts to be tightened, screws to be driven, loads to be lifted or surfaces to be smoothed and painted, Atlas Copco can supply reliable, high-performance, air-powered equipment, together with stationary compressors for every requirement from operating a spray gun, to supplying the complete air needs of a large factory.

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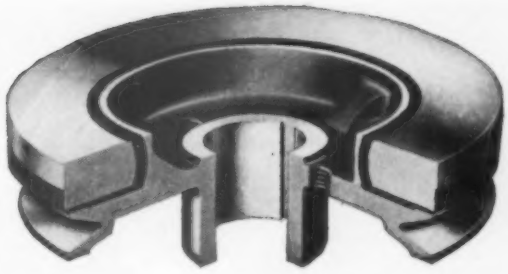
HOLSET
NON-BONDED CRANKSHAFT DAMPERS



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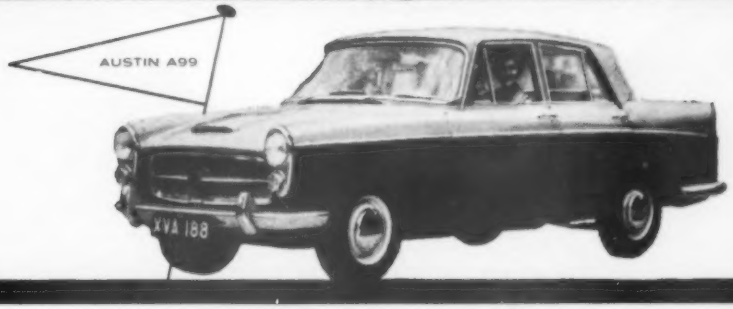

The Holset Non-bonded Crankshaft Damper is a combined torsional vibration damper and pulley ready balanced and assembled for fitting to the engine.

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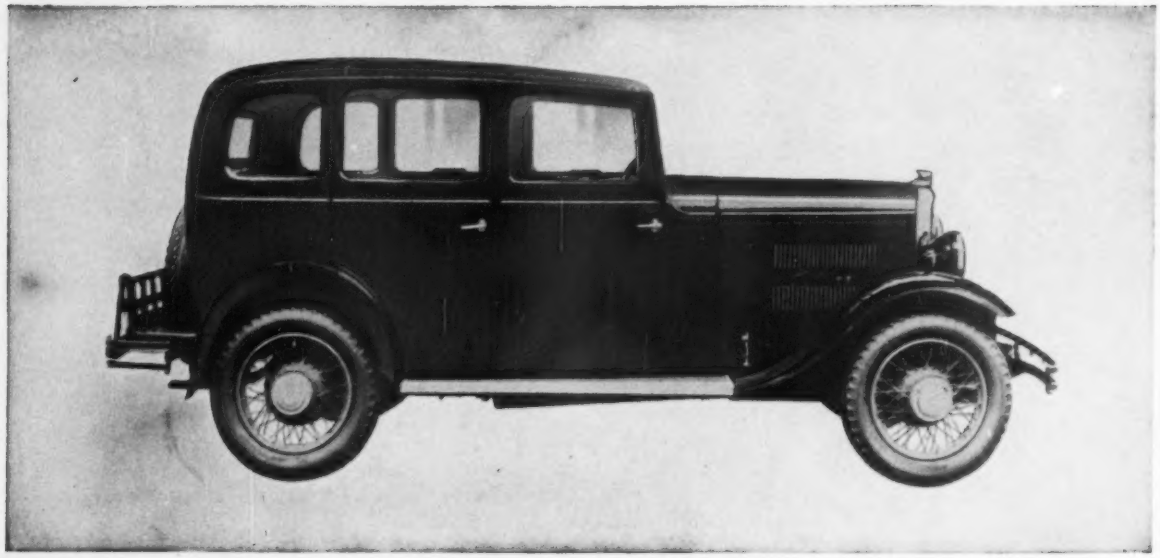

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Inheriting the accumulated experience from many years of specialization in vacuum servo devices, this Lockheed 5½-inch servo is identical in its operation with the previous Lockheed servo units, but in view of its lighter duty has a diaphragm instead of a piston.

The servo is extremely effective and progressive, it is compact and easily installed. In the event of vacuum failing, normal hydraulic operation remains unimpaired.

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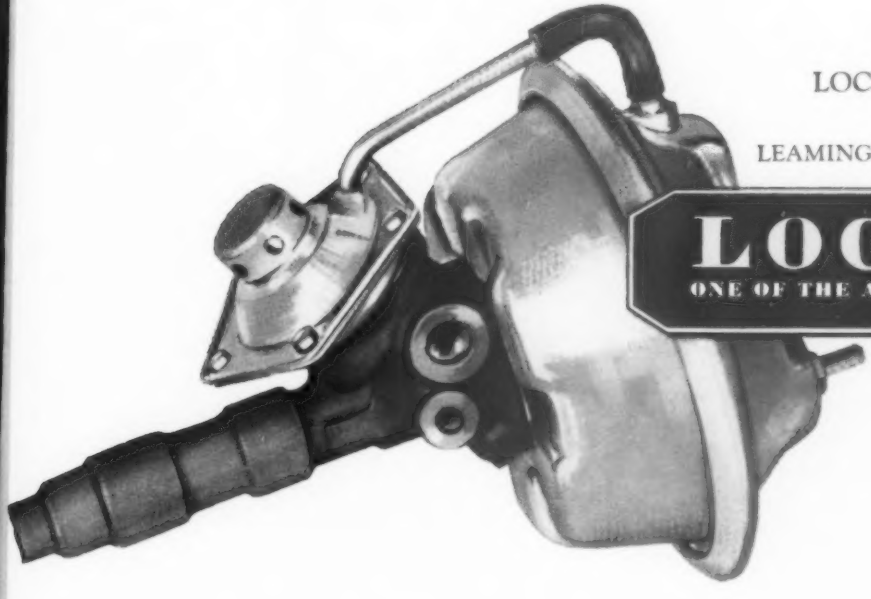

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8″–8½″ STRAP DRIVE

The self-centring frictionless strap drive to the pressure plate, having proved its great value, has been incorporated in this 8″–8½″ clutch. The clutch can be installed in the bell housing that takes the standard Borg & Beck 8″ A.6 clutch; the flywheel and release bearing used are also the same.

Also available with 8″ or 8½″ driven-plate.

The Borg & Beck range also includes other strap-drive clutches in sizes from 12″ to 17″ and the A-type in sizes from 6¼″ to 11″.

There is also the 18″ R.4 heavy-duty clutch available in single or twin-plate type.

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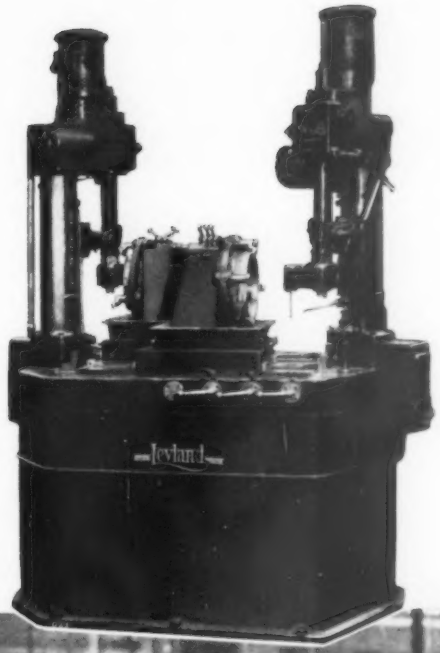
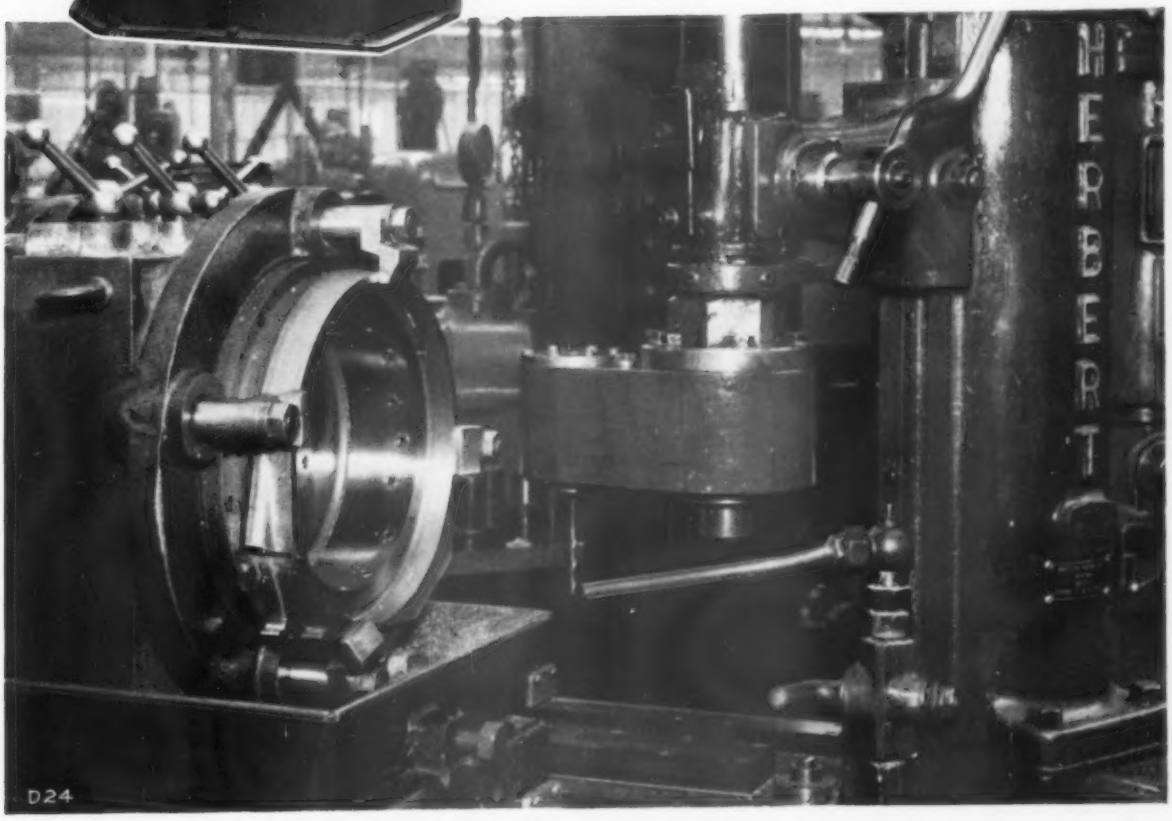


— assembled to customers drilling requirements

Herbert All-electric Drilling Machines are made in ten types for drilling holes from the very smallest, at 18,000 r.p.m. up to $1\frac{1}{4}$" diameter.

This equipment meets all general purpose requirements. Unit construction and interchangeability enables special requirements to be easily met.

We will quote for machines and equipment to meet special requirements for drilling, tapping and associated operations.



Leyland Motors Ltd. use two Herbert Type C top columns on a common base equipped with duplicate fixtures for high production drilling of nineteen $\frac{11}{16}$" diameter rivet holes in external brake bands. There are three series of holes in each band.

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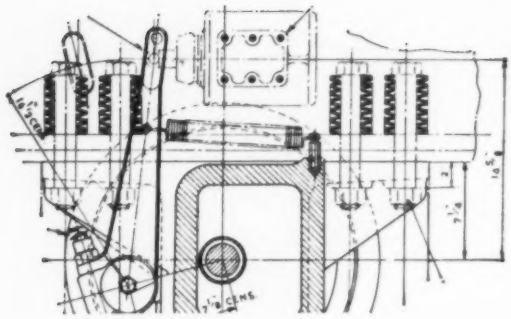
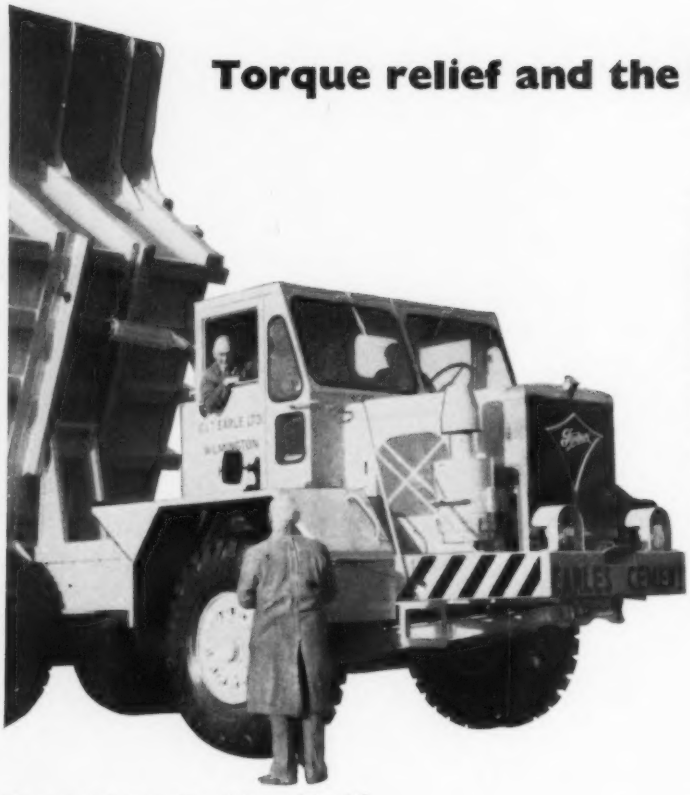


Torque relief and the Belleville Washer



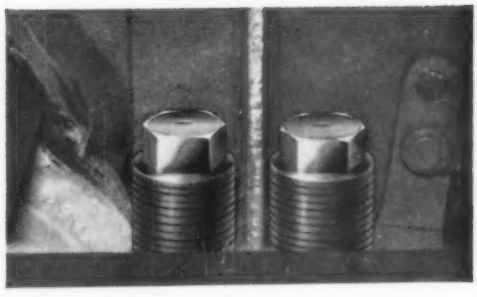
Illustrations by kind permission of Messrs. Fodens Ltd.

Messrs. Fodens Ltd., fit Belleville washers in packs of 7 pairs on their F.R.6/45 Heavy Duty Dumper. This proved to be the most effective method of relieving twisting of the rear axle case produced by braking and transmission torques.

The potential uses of Belleville washers are endless.

They provide the perfect answer to engineering problems where resistance to load or thrust is beyond the capacity of helical springs. Their fractional movement under heavy load has solved design difficulties in almost every industry.

Salter technicians can help you. Their services are freely at your disposal.



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Patrician Pastry chauffeured in style by Carefree Pastry, in the 1907 *Daimler* TP 35. Generating 35 h.p. on four cylinders, this classic *Daimler* is on display at the Montague Motor Museum.

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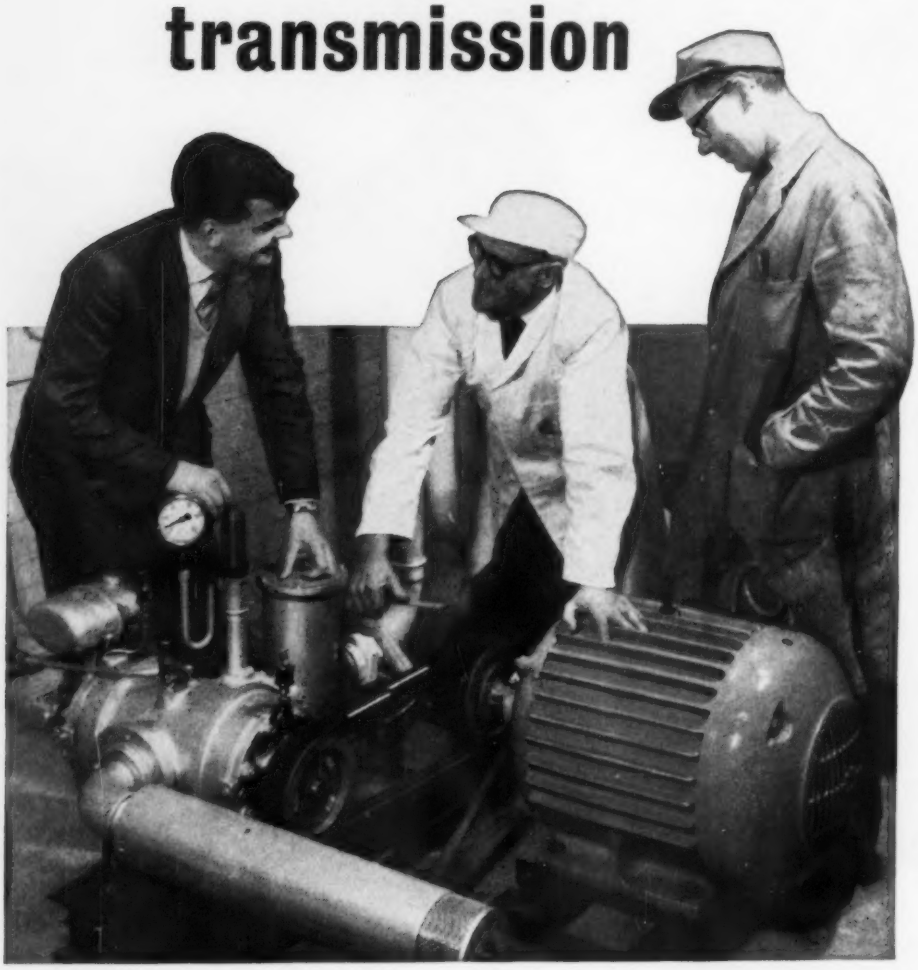
The transistor of power transmission



This SpacesaVer wedge-belt drive transmits 25 h.p.—in the space of three fingers!

Look how SpacesaVer Wedge-belt Drives are already proving their worth.
Scottish Agricultural Industries Ltd. of Glasgow were recently faced with an unusually difficult problem. An air blower, directly-driven by a 25 h.p. motor, had to be stepped up in speed from 1480 to 1660 r.p.m., but the shaft extension was only $2\frac{1}{4}$". Even so, a SpacesaVer drive of 25 h.p. capacity could be mounted. SpacesaVer pulleys 9" and 8" diameter (face width 2.73, boss length $1\frac{3}{4}$") and three No. 710 Beta-section belts did the trick. In fact, as the works' engineers then commented, "SpacesaVer is the complete answer . . ."

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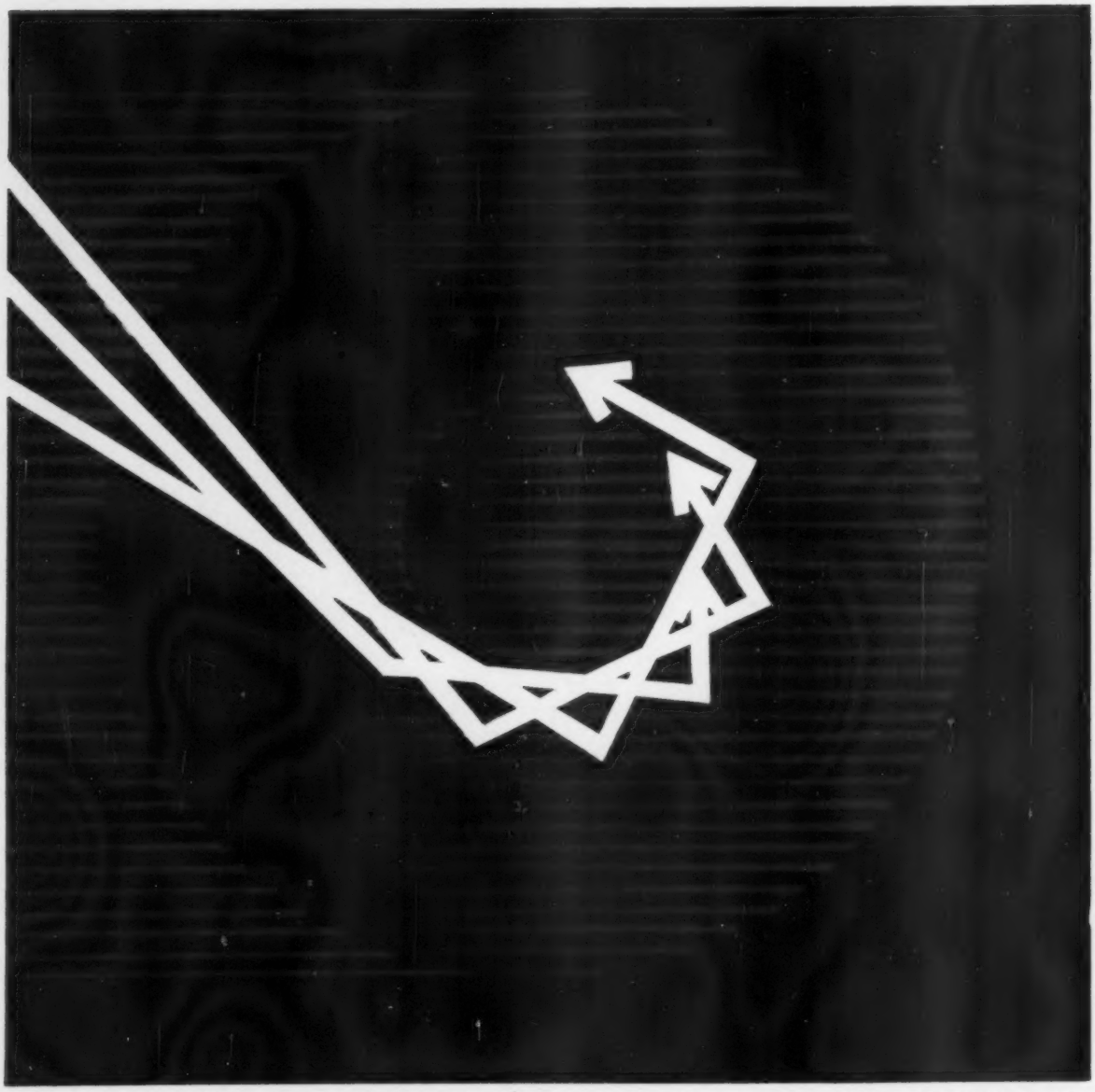

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TA 4883

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SIZE 24

Extra strong in design and construction this tool incorporates longer normal working life with minimum maintenance.

Basically designed as a Nut Setting Tool, this Impact Wrench may be effectively used with the available attachments for screwdriving, tapping, drilling, grinding, wire-brushing or sanding.

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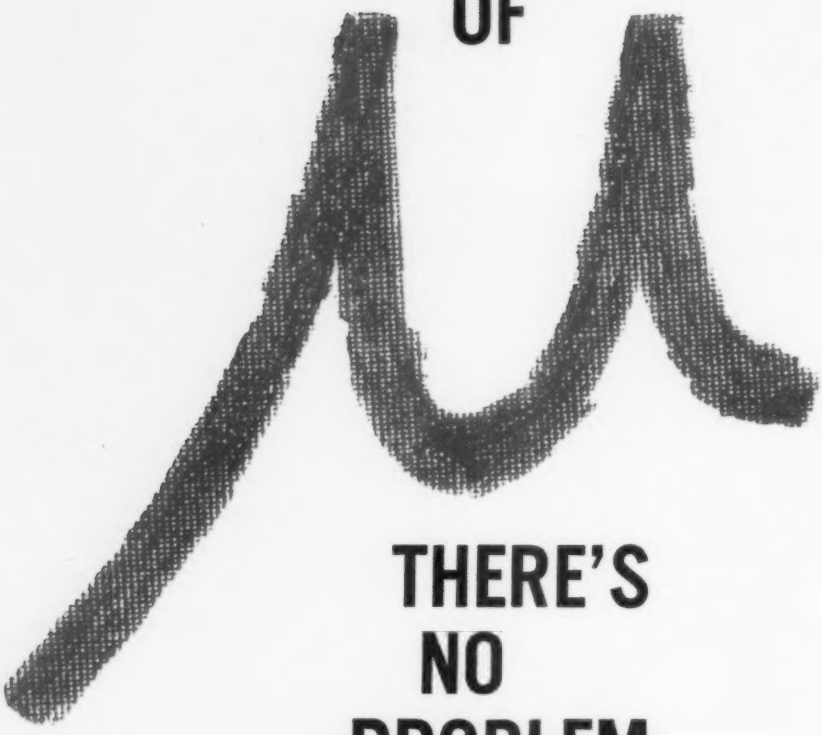
IF IT'S A PROBLEM OF



THERE'S NO PROBLEM

μ has many meanings. One of the most mysterious things it symbolises is friction. No-one knows exactly what friction is; but you know some of the problems and possibilities it presents.

Ferodo is well equipped to find answers to the problems, and ways of exploiting the possibilities.

Think of our background: it includes every aspect of friction and friction materials for brakes and clutches. We manufacture every established type of friction material, from the most conventional to sintered metals and cermets.

Better still, we devote an unusually large proportion of effort, equipment and money to our research laboratories—incomparably the finest of their kind in the world.

And all these production and research resources can be put to work for you.

FOR EXAMPLE . . .

Automatic Transmissions commonly depend on a multiplicity of drive and control systems, each with its own special friction problems demanding materials with individual characteristics. So far, these demands have been met by Ferodo materials of one sort or another. But perhaps you have a special problem?

Earth-Moving Machinery poses enormous problems in terms of wear resistance and high-temperature stability of friction materials. Ferodo sintered metal facings and Ferodo cermets are providing some striking solutions—and probably any problem inherent in automotive clutch designs for heavy duty can be met by them. Is this your problem?

Friction Materials themselves may suggest simplified answers to apparently complicated questions. We believe that many brake, clutch and transmission problems could be solved more quickly by designing round the friction materials available. Would you like to consult us at the design stage?

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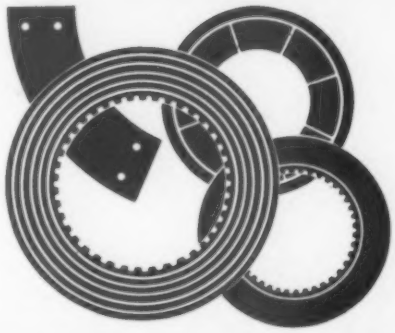

Remember—only Ferodo manufacture a complete range of friction materials: and therefore only Ferodo can promise completely unbiased advice on friction problems. You are cordially invited to bring us such problems.

ask Ferodo First!

FERODO FRICTION MATERIALS

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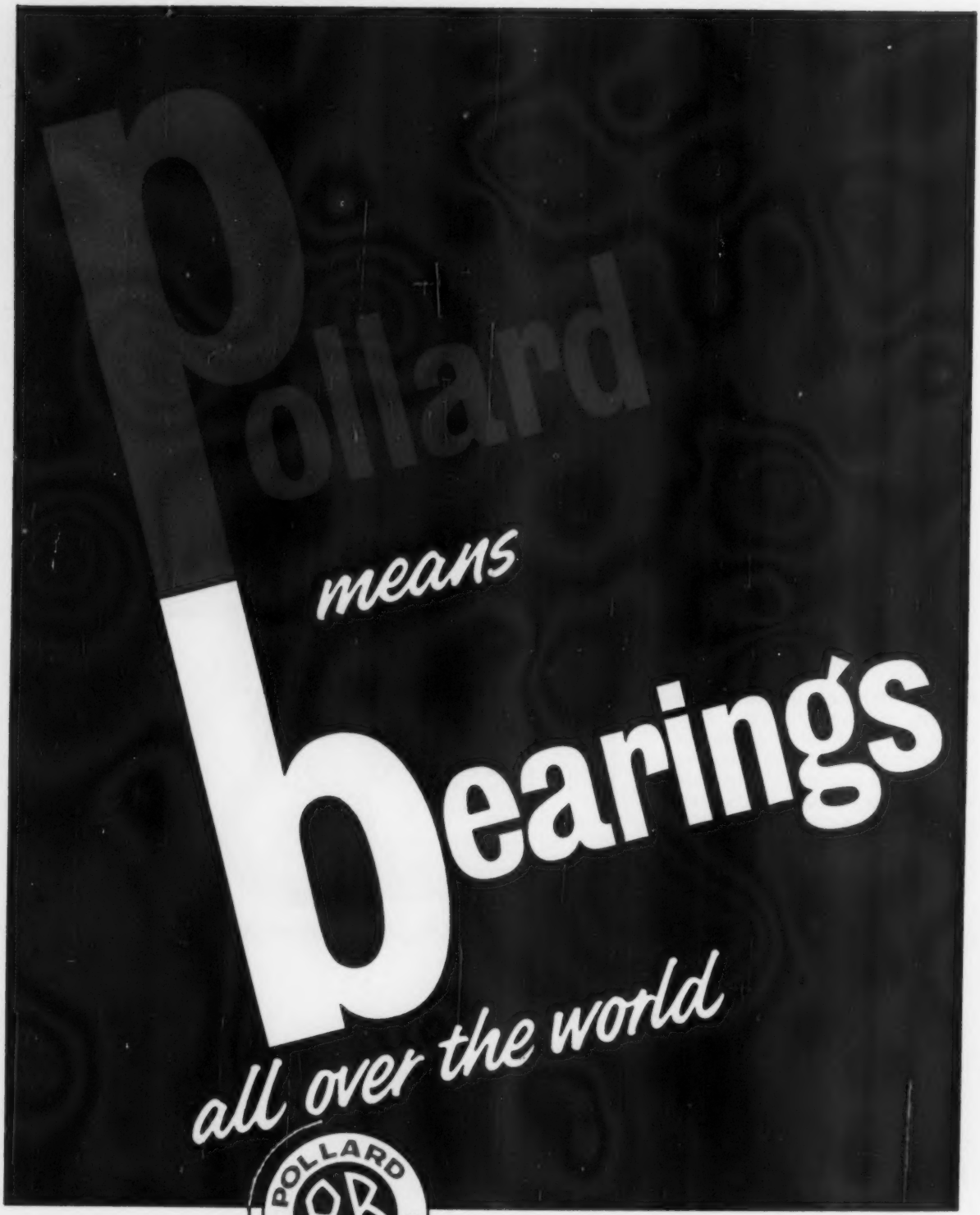

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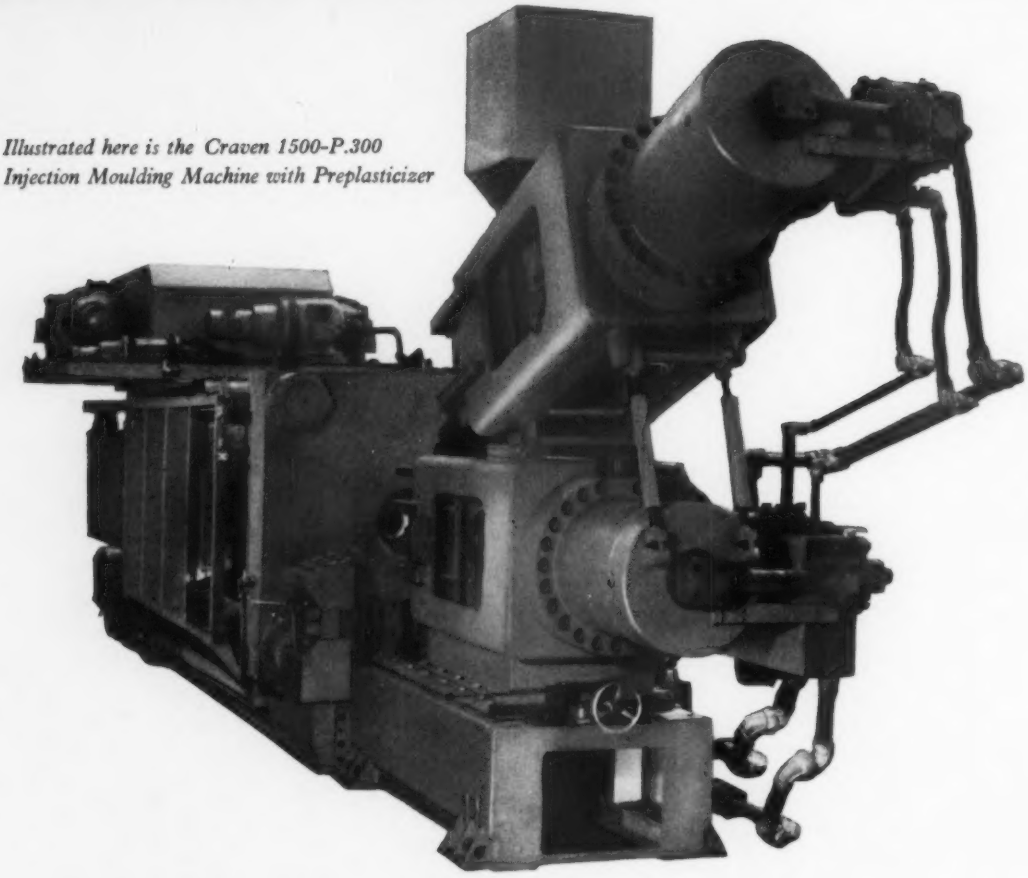

Illustrated here is the Craven 1500-P.300 Injection Moulding Machine with Preplasticizer

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In order to increase the range of their comprehensive custom moulding service and for use on special projects Thermo Plastics Ltd. — *chose a*

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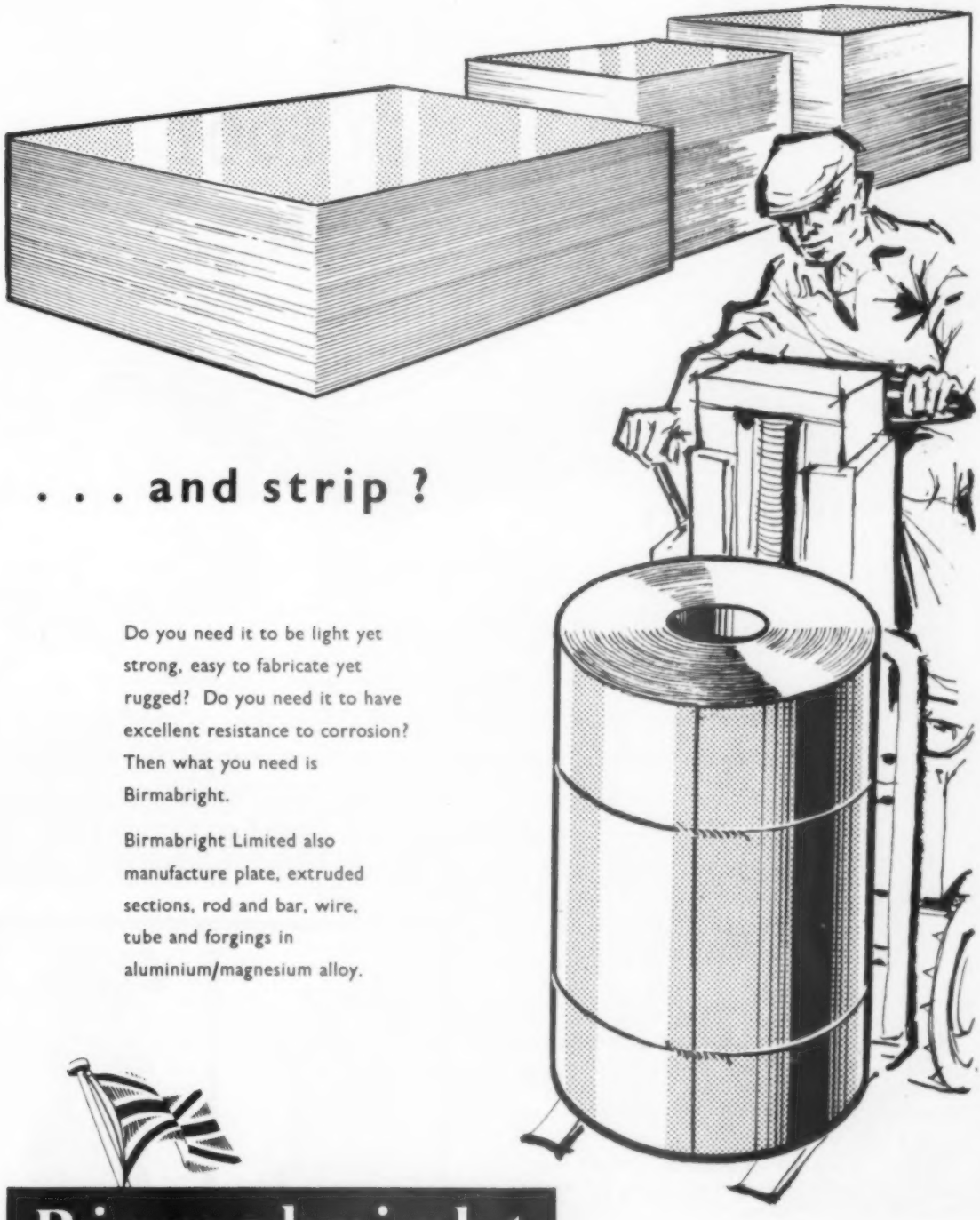

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Do you need it to be light yet strong, easy to fabricate yet rugged? Do you need it to have excellent resistance to corrosion? Then what you need is Birmabright.

Birmabright Limited also manufacture plate, extruded sections, rod and bar, wire, tube and forgings in aluminium/magnesium alloy.

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DAISY PUTS HER FOOT DOWN...

It's as simple as that! A gentle pressure from Daisy's foot releases up to 12,000 lbs. pressure. Daisy's happy and so is her boss. He installed a **FUNDITOR MARKING MACHINE** which takes all the hard work out of Daisy's job and, of course, the boss knows he'll get a faster, better and absolutely reliable job done. Why not send for a copy of the **FUNDITOR MARKING MANUAL** containing over 100 illustrations.

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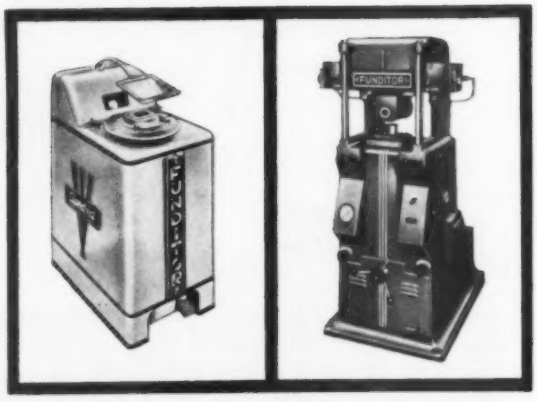
Primarily intended for deep marking where a high marking rate of consistent clarity is required.



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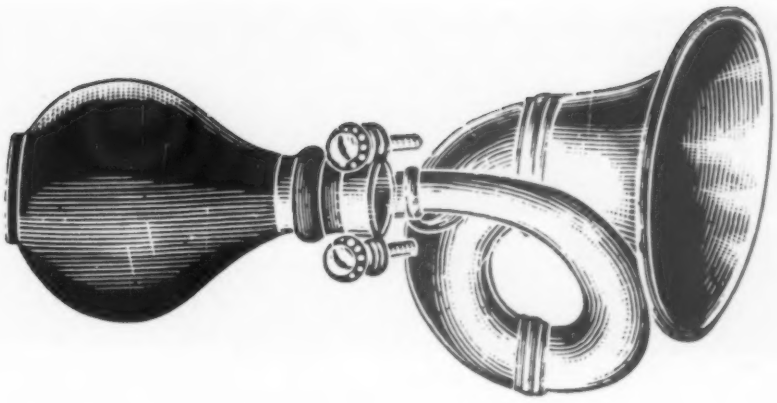

Klaxon — a 6 m.p.h. rarity.

Today, when cars are no longer a rarity, it is not enough to let a car blow its own horn.

With today's competitive market, it requires the power of publicity. Television is the key. It is far and away the most effective medium for actually demonstrating cars and components to potential customers in their homes.

Manufacturers and dealers advertising on Associated-Rediffusion reach over 8 million people in the London area—a prosperous market, proved by the fact that 25% of all car owners in this area purchased their cars in 1959.

And, did you know that 32% of cars in the area are now due for testing? Here is your opportunity to sell the economies of running new cars—your cars.

AGE OF CAR OWNED	Total	Class			
		AB	C	D1	D2E
No. of car owners	396	93	114	90	39
Percentage of cars over 10 years old	32%	20%	27%	43%	49%

Make sure that you capture your share of this market by advertising on television—on Associated-Rediffusion.

These figures are quoted from the London Viewership Survey No. 3, commissioned by Associated-Rediffusion.
Eric Laman (Telephone: HOLborn 7888) will be pleased to give you more details of your potential London market.

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Simms — Bendix

A STATEMENT

Simms Motor Units Limited of East Finchley, London, N.2, and the Bendix Corporation of Detroit, Michigan, U.S.A., announce that they have entered into an Agreement under which Simms grant to Bendix an exclusive manufacturing licence and selling rights throughout the United States of America of their diesel Fuel Injection equipment. The range of products involved embraces In-Line and Distributor Fuel Injection Pumps, Governors, Injectors, Filters and Couplings—a number of which are items which Simms are already exporting to America.

The Bendix Corporation have acquired at the same time non-exclusive selling rights of this equipment in Canada, Mexico and Brazil. They also assume complete responsibility for servicing throughout the area. Both the British and the American companies are confident that their association will lead to a great increase in sales of Simms equipment in the territories involved.

The Bendix Corporation

The giant Bendix Corporation is one of America's most powerful and widespread industrial groups, incorporating forty Divisions, Subsidiaries and Affiliated Companies.

Its engineering staff numbers more than 6,000 specialists backed by the unique facilities at their disposal in 15 research laboratories in addition to a complete Research Division engaged in experimental work in many advanced fields. Twenty-five coast-to-coast Bendix divisions employ over 42,000 skilled operatives. Last year, Bendix sales reached the impressive value of $792,000,000.

The name Simms has been in the forefront of the British Motor Industry ever since its inception 70 years ago. Indeed, it was the founder of the Company, the late Frederick R. Simms, who also founded the Industry's governing body, the Society of Motor Manufacturers and Traders, and also the governing body of British motoring sport, the Royal Automobile Club.

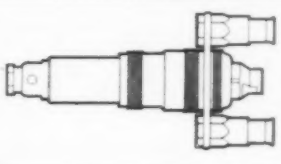
In the specialised field of pumps for diesel application Simms are large suppliers to Ford Motor Company, British Motor Corporation, General Motors, Leyland, A.E.C., Rolls-Royce, and many others, and they stand to-day as one of the world's largest manufacturers.

The Simms-Bendix link-up is of the utmost importance to Britain and its many implications will at once be apparent to students of international commerce.

up desoutter

THE MANAGING DIRECTOR is most excited about all this Rockets-to-the-Moon business. With reason! Millions of holes in these are being drilled by Desoutter Drills and filled by Desoutter Screwdrivers and Nut Runners. He says any moment these Rockets will be swooshing off with men aboard (and he hopes Ladies too and a Small but well-stocked Bar) to all parts of the Universe. He says he will gladly be a passenger on any of them with a slight leaning towards Venus.

("The old goat!" muttered a faithful employee).



The P.56M Rivet Miller is used by English Electric Aviation Ltd. in the manufacture of the Thunderbird.

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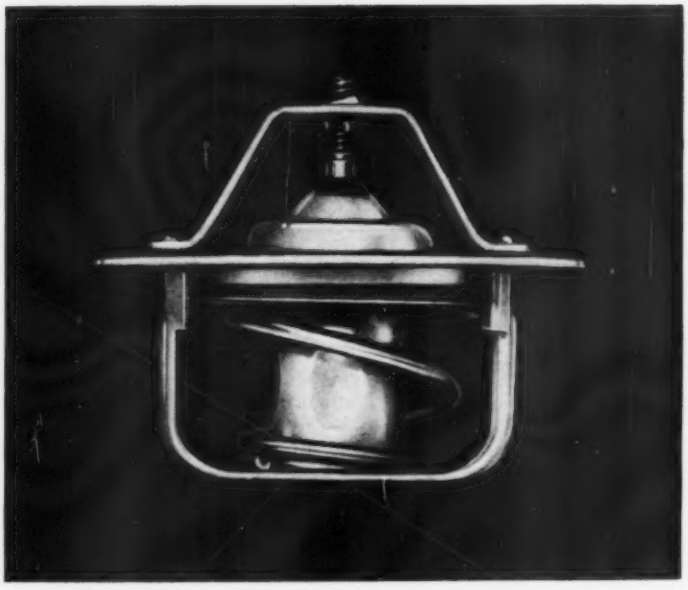
NOW ROOTES GROUP SPECIFY WESTERN THOMSON WAX ELEMENT THERMOSTATS

Many other manufacturers specify Western Thomson for their pressurised engine coolant systems including Rolls-Royce, Alfa Romeo, Jaguar, Leyland, Fodens, Perkins, Petters and David Brown.

Western Thomson wax element thermostats are specially built to withstand pressure and vibration. They are simple and robust. They are actuated by the expansion of solid wax, and they have no stressed metal parts to suffer fatigue. Consequently, they give long trouble-free service in engine-cooling systems.

Available for use with or without a by-pass, and start-to-open temperature setting from 85° to 185°F.



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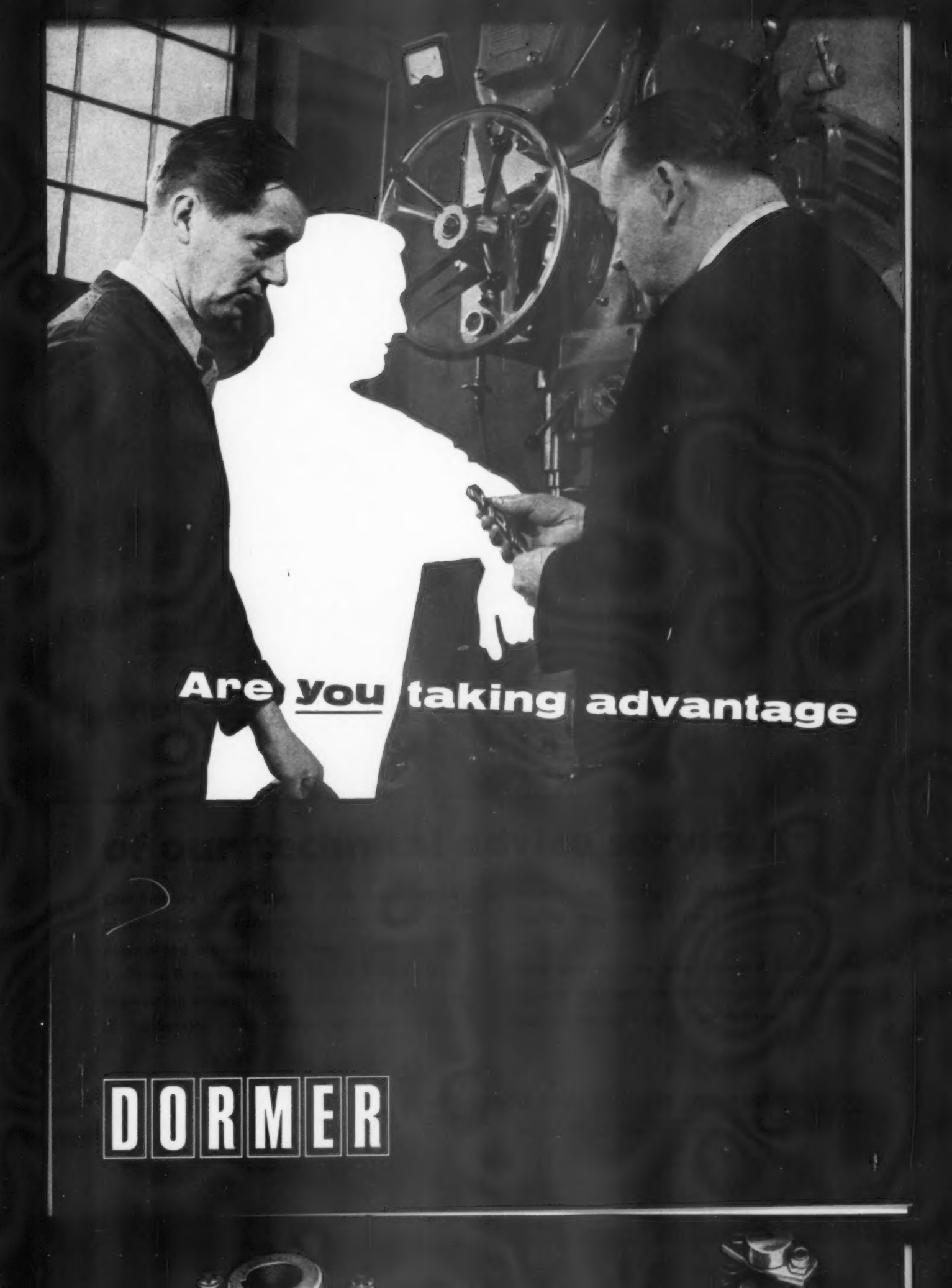

DORMER

Bonding a sealing strip in the weather channel round the engine of an Austin 7 with adhesive based on Du Pont neoprene.

HOW AN ADHESIVE BASED ON NEOPRENE SOLVED AUSTIN'S BONDING PROBLEMS

At the Austin Motor Company's works at Longbridge, Birmingham, a large number of the assembly jobs involve bonding. Roof-linings, dashboard fittings and some weather-stripping require a secure and lasting bond.

■ Up until 1958 many different types of adhesives were in use, rendering both the assembly work and the stock position unnecessarily complex. These were two of the reasons why the British Motor Corporation seized the opportunity to change to a neoprene-based adhesive that would do all the jobs previously done by a large variety of rubbers and cements.

■ Du Pont neoprene is chemically stable and will dissolve in solvents and solvent mixtures to give adhesive solutions of varying viscosities and drying rates. It can be compounded to form the ideal adhesive for an almost limitless range of materials. For leathercloth in particular a neoprene-based adhesive is recommended. It will not weaken with age or degenerate under those extreme conditions of weather to which exported vehicles are often subject. Bonds effected by solvent adhesives based on Du Pont neoprene are also highly resistant to degradation by oils, chemicals and water, as well as heat, sunlight and ozone.

■ To find out how adhesives based on Du Pont neoprene can solve *your* bonding problems, send the coupon below for further information and list of suppliers to the Du Pont Company (United Kingdom) Ltd., 76 Jermyn Street, London, S.W.1.

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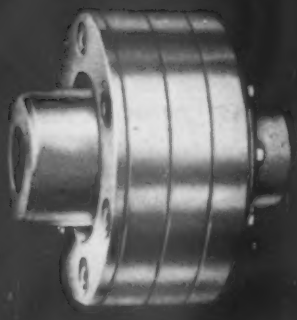

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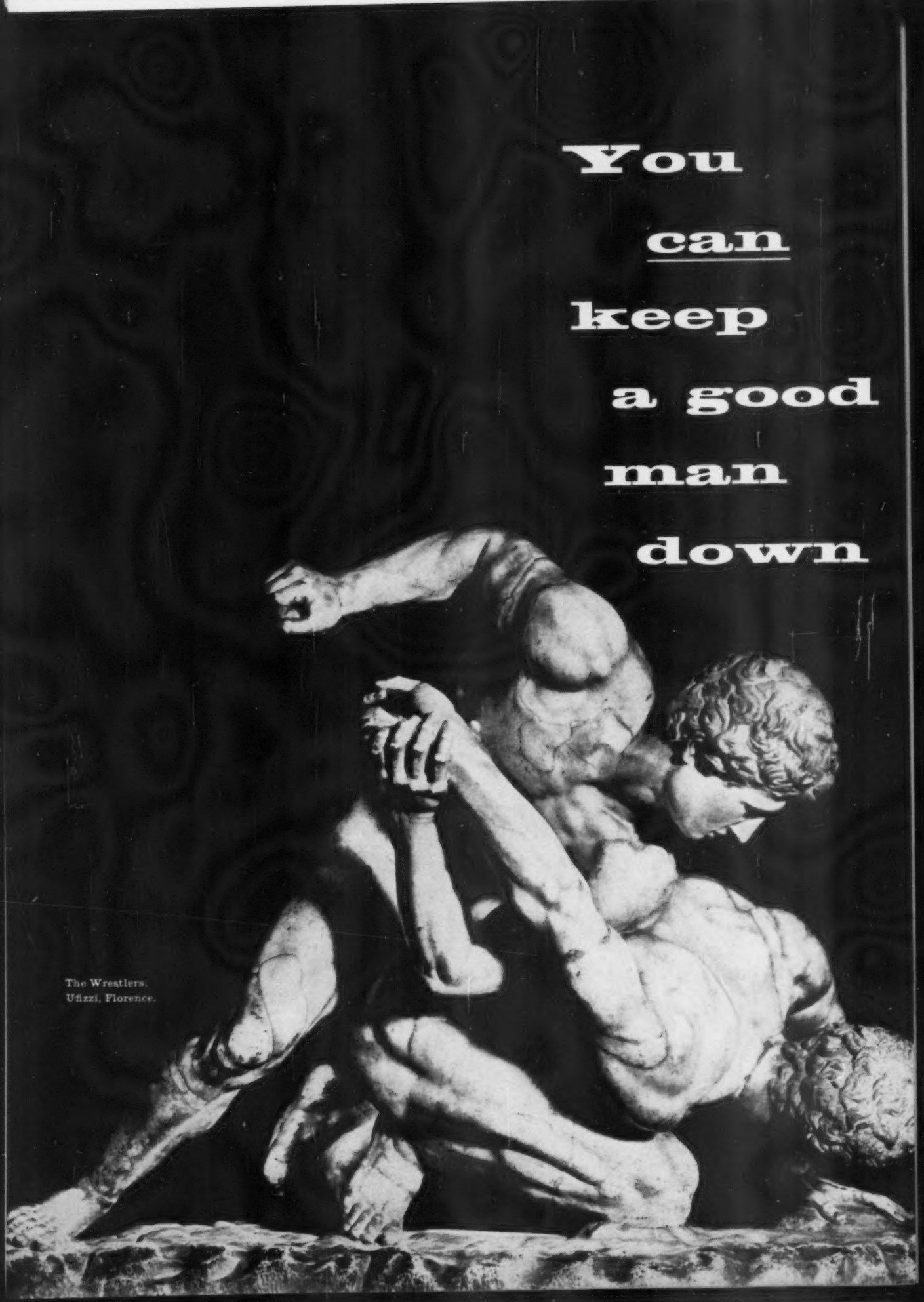
You can keep a good man down



The Wrestlers.
Ufizzi, Florence.

One way of keeping a good man tied down is to have him wrestle with a welter of competing firms all peddling different pieces of finishing equipment. He gets involved in a mass of unnecessary detail which tends to obscure the overall picture of a complete finishing system. That is why so many leading manufacturers have released their staff from the pressure of product finishing detail by delegating the whole responsibility to a single specialist organisation—Lysaght-DeVilbiss.

With over fifty years' specialised experience of product finishing in it's broadest aspects, this organisation has the know-how and skill to provide the complete system best suited to your product. Lysaght-DeVilbiss design, manufacture and install complete product finishing systems from metal pre-treatment to final stoving. For a sound, unbiased opinion, get on to Lysaght-DeVilbiss. No obligation, of course.

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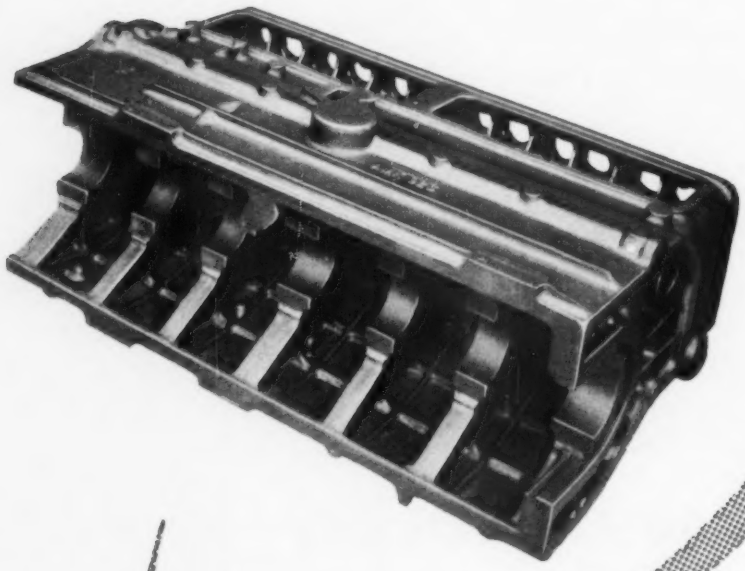

Morris Commercial
Oil Engine Block in Cast Iron.
By courtesy of B.M.C Limited.

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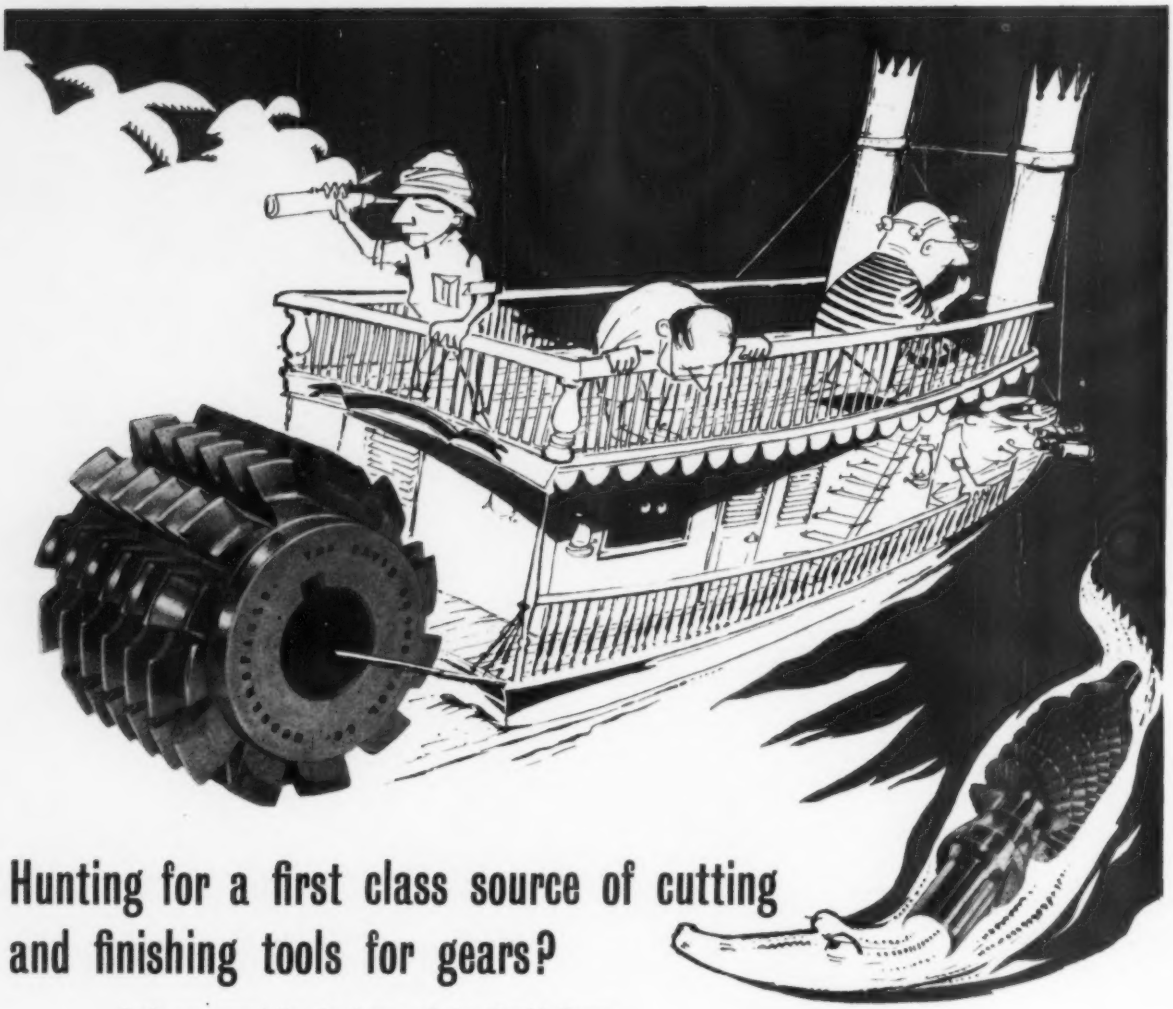

Hunting for a first class source of cutting and finishing tools for gears?

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TOOL DIVISION PARK WORKS HUDDERSFIELD
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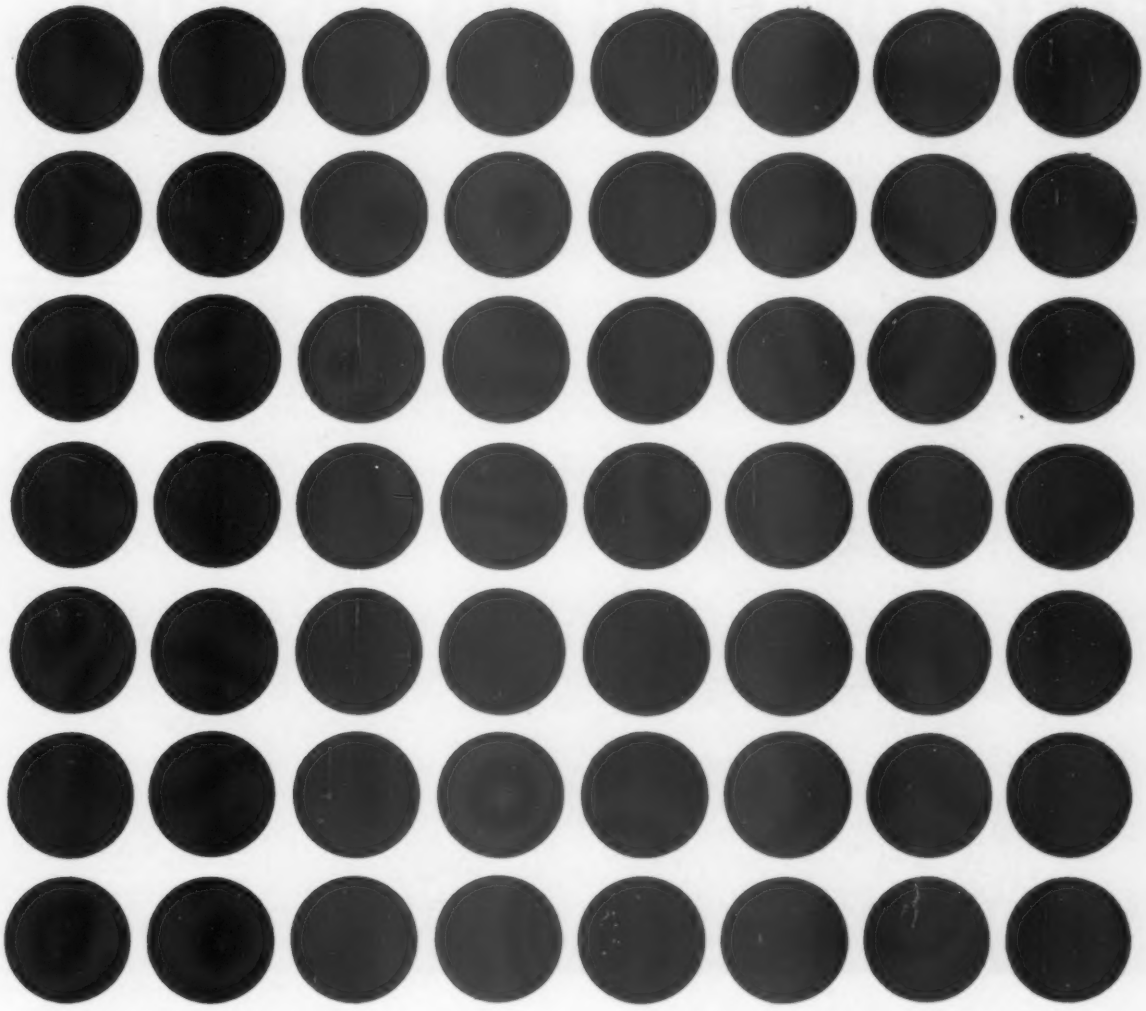
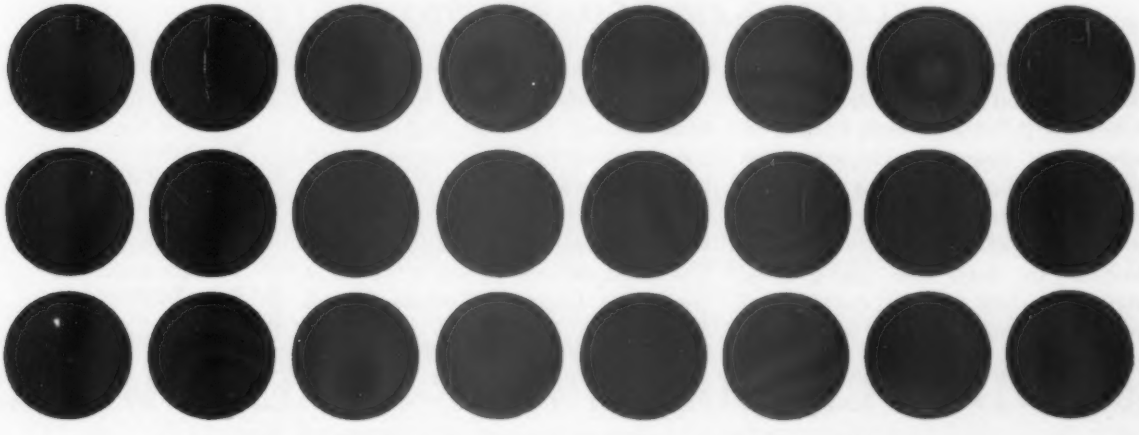


Perfect repetition — as provided by Araldite epoxy resins for jigs, fixtures and press tools. Replicas cast in Araldite are quickly and economically produced; they do not shrink on setting, and are resistant to damp and chemical attack.



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AP 553

EASIER DRAWING AND PRESSING...

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Another reason why industry is changing over to

DRAGONITE

ELECTRO-ZINC COATED SHEET STEEL

DRAGONITE is sheet steel which has been given a coating of pure zinc on both faces. It has a number of advantages over ordinary, uncoated sheet steel. During drawing and pressing operations, for instance, the surface properties of Dragonite are maintained. In fact, the fine-grained structure and natural ductility of pure zinc actually *assist* fabrication by acting as a dry, solid lubricant.

This exceptional ductility of Dragonite cuts manufacturing costs because it makes longer press runs possible and lengthens tool life.

There are many more good reasons why you should be using Dragonite. For fuller details, please write for a copy of the *Dragonite Technical Handbook* to:

These are some of the industries in which Dragonite is being used extensively: Office Equipment; Elevators; Agricultural Equipment; Automobile Industry; Domestic Appliances, Radio Equipment, etc.

THE STEEL COMPANY OF WALES LIMITED

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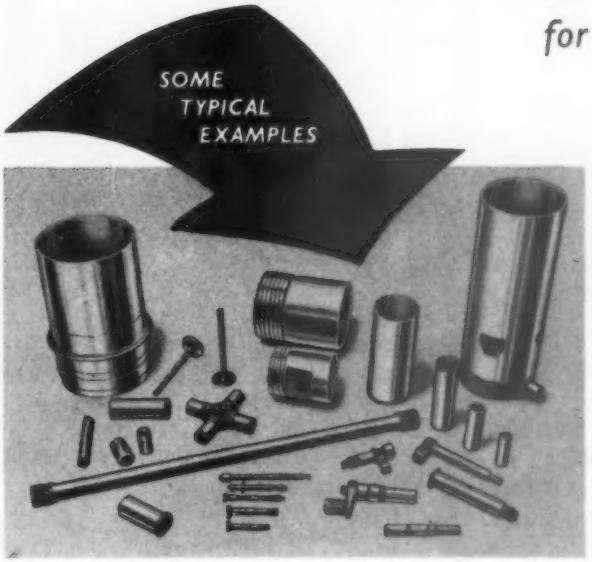
LIDKOPING

CENTRELESS GRINDING MACHINES

for accurate, high-output production



The type 4B machine illustrated is widely employed for production of automobile components and is also a popular machine for the electrical and textile industries. in fact, wherever high output, close tolerance centreless grinding is required.

The grinding and regulating spindles are supported at both ends in super-precision roller bearings of equal resistance and the grinding wheel spindle drive is through a torsion bar to relieve the spindle of belt tension. The range of work diameters which can be ground on the 4B machine is 0·04 in.—6 in. and maximum length for infeed work is 11·8 in.

Write to-day for full details of the Lidkoping range of centreless grinding machines.

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Member of the Asquith Machine Tool Corporation

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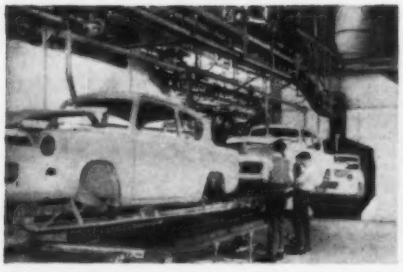
WHODUNITRY or who solved the problem?

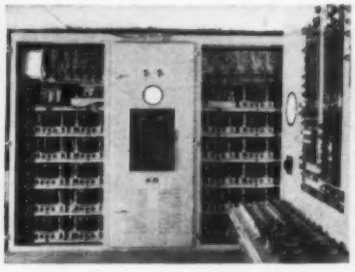
In the 'good' old days when labour was indeed hard LABOUR! and factory space was overloaded with cumbersome machinery, engineers were beset by many problems, tending more and more towards AUTOMATIC speed-variation and speed-control.

Many of these problems could not be solved by conventional electric or hydraulic drives, but they have yielded to the skill and experience behind the

HEENAN DRIVES

— the AJUSTO-SPEDE, DYNASPEDE





FORD too – have chosen Heenan Variable-Speed Couplings, for driving the Conveyors in their new Paint, Trim and Final Assembly building. These Drives are also in use at their Associate Company's Australian Plant. Heenan Drives have been supplied to the major car manufacturers including B.M.C. (Austin and Morris), STANDARD, VAUXHALL, SIMCA, VOLVO, etc., etc.

Remember - There is no substitute for experience

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THE GIRLING TANDEM MASTER CYLINDER

The advantages!

1. *Additional Safety.*
The Tandem Master Cylinder operates the hydraulic systems to front and rear axles independently, and therefore provides a safety factor in the event of failure in either of the two circuits.

2. *More Efficiency—Less Maintenance.*
Because there are no moving seals in the bore, the degree of efficiency and consistency is increased and, as risk of scoring the bore is eliminated, maintenance is greatly reduced.

3. *Extra Life.*
As there is very little difference in the hydraulic pressure between the two chambers, the seal dividing them is not subjected to any pressure differential from side to side. This balanced pressure across the seal ensures longer seal life.

4. *Simultaneous Operation — Less Pedal Travel.*
Unlike other tandem master cylinders where the valves operate in sequence, giving a double cut-off effect, the valves of the Girling Tandem Master Cylinder operate simultaneously, giving a single cut-off effect. As cut-off represents ineffective pedal travel, it will be seen that the loss due to cut-off is virtually halved when using the Girling Tandem Master Cylinder.

5. *No Air Problems.*
A special self-bleeding characteristic facilitates easy bleeding of the hydraulic circuit and also ensures that should air gain access to the cylinders it can readily escape, thus eliminating loss of efficiency which could possibly occur in this way.

Many years of patient research and constant development have made it possible for Girling to announce this new tandem master cylinder. It has all the advantages of previous models but, in addition, gives completely independent hydraulic supply lines to front and rear axles from one unit, and therefore provides an inherent safety feature in the event of failure in either hydraulic circuit. In addition the design incorporates a number of other important features which increase reliability of operation and reduce maintenance. This new unit is indeed a worthy complement to the highest standards set by Girling brakes today—THE BEST BRAKES IN THE WORLD.

GIRLING

THE BEST BRAKES IN THE WORLD

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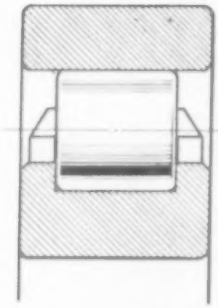
SM/B6194

R&M parallel roller bearings

meet the case, when shock loads occur, and shafts expand or contract



These bearings are in earthworking and bulk handling equipment, in vibrating screens, electric motors and other machines of all shapes and purposes.

Parallel roller bearings made by Ransome & Marles possess exceptional advantages. Most, for example, incorporate the exclusive R&M broached cage which increases the unit's strength/weight ratio; there are super-blended rollers for exacting applications, single and double row series, self-aligning bearings—bearings of all sizes and capacities.

Publication 37 is a comprehensive guide. Consult the R&M Technical Department for advice or assistance of any kind to do with bearings. Ransome & Marles knowledge is at your disposal without charge or obligation, and your enquiry will, of course, be treated as confidential.

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There are two Shell Rotella Multigrade Oils:

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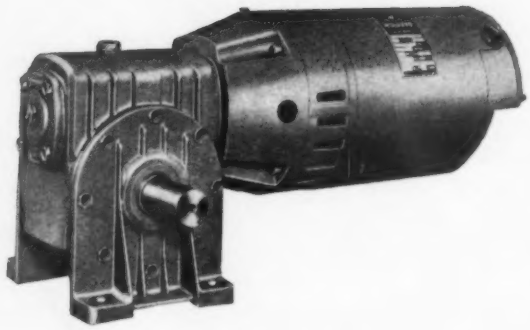
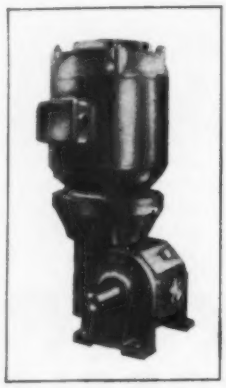
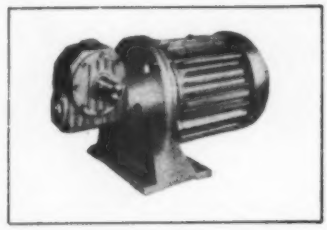


This new Holroyd 2¼" centres motorised worm gear speed reducer has been designed to meet the need for a self-contained drive suitable for continuous use, and one which will look right in any surroundings. No matter what the application, it is possible to select from its variety of assemblies and mounting positions, an arrangement which makes it appear an integral part of the surrounding machinery, and *not* an added afterthought.
The Verso has all the famous features of Holroyd reliability and high efficiency. Centrifugally cast Holfos wormwheel; casehardened and profile ground alloy steel worm; ball bearings throughout; rigid cast iron casing and oil bath lubrication requiring no attention over long periods. Output speeds are from 14 to 300 rpm. Output torques up to 750 lb. ins. Standard motors from ¼ up to 2 hp.
Please write for catalogue V.60 which gives further technical information.





Holroyd

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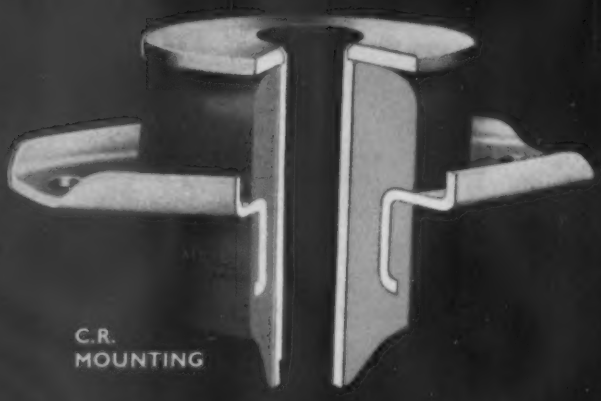
METACONE MOUNTING



C.R. MOUNTING

For Cabs and Bodies

METALASTIK MOUNTINGS

Metalastik mountings play a double part in damping out vibration and shocks and reducing noise level. They help to give a better ride to the load which may range from the injured in an ambulance to sensitive electronic equipment and they prolong the life of coachwork and tanks by reducing local racking stresses.

The Metacone mounting is used extensively for widely different types of body. Providing substantial deflections with high load capacity, its progressive action and inherent damping are of great value.

Specially designed by Metalastik after long study of the problems involved in mounting cabs, the C.R. mounting is fitted by leading vehicle manufacturers. It reduces transmitted noise, softens shocks and controls rebound. There are many other mountings available. As a trunnion mounting or pivot for tanks, the Metalastik Ultra-Duty bush permits large torsional deflections and supports heavy radial loads. Cushyfoot mountings are ideal for mobile generators, compressors etc., and for lighter loads there is the low-height equi-frequency mounting with built-in rebound control as used for the sub-frame on the Rover 3-litre car.

Ultra-Duty bushes are employed for mounting aluminium tanks by Thompson Bros. (Bilston) Ltd. The Dennis ambulance chassis incorporates eight Metacone mountings to give smoother riding for the injured. Metacone mountings are used on the Tecalemit crashtender for cab and tank but they are larger than those on the ambulance because of severe shock loads on cross-country travel.

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in Natural, Synthetic and Silicone Rubbers.
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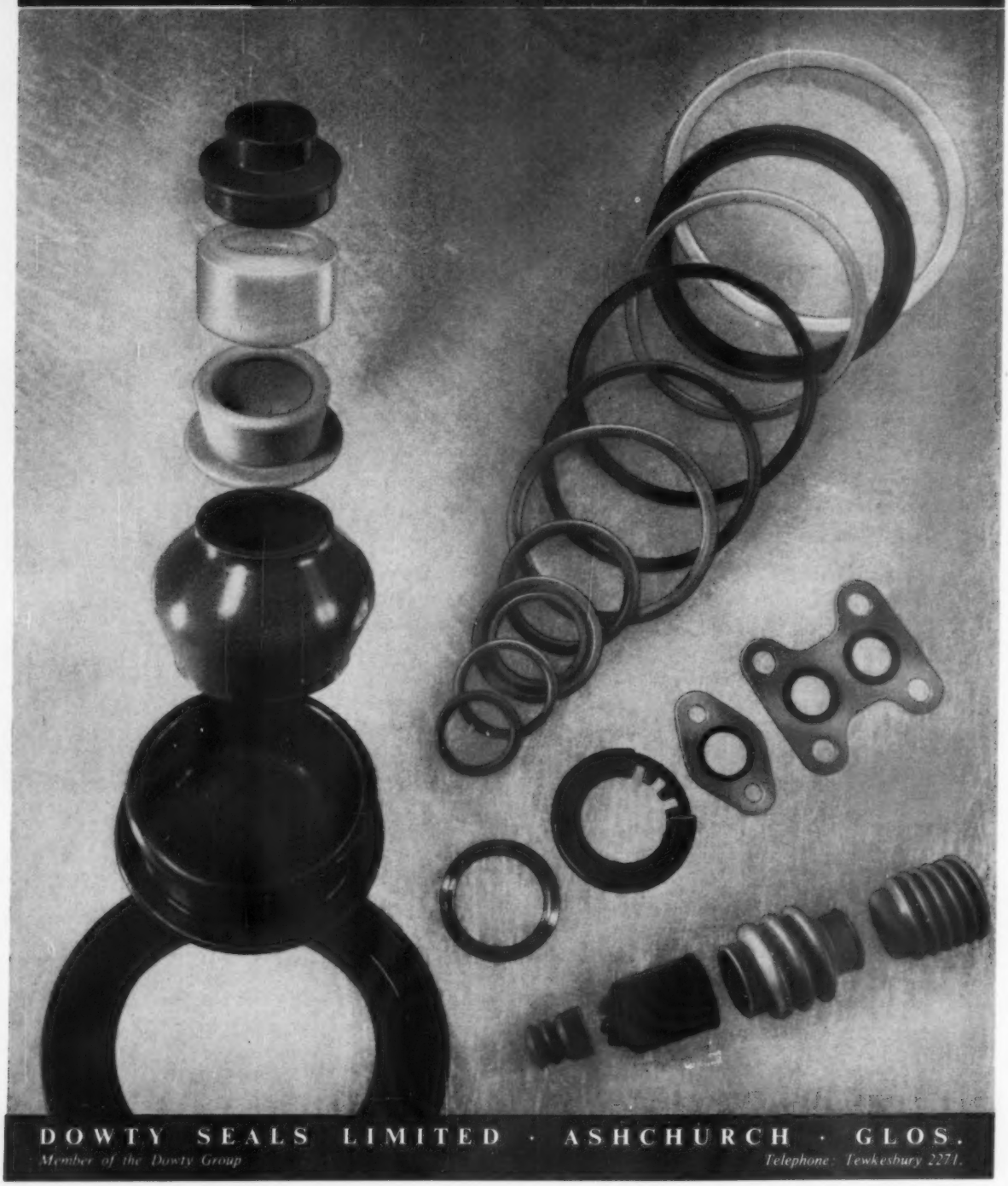

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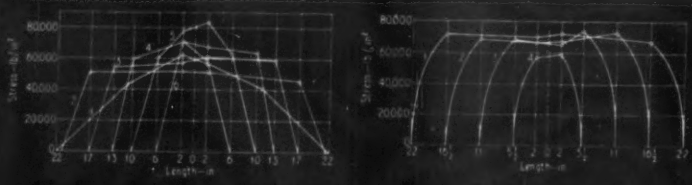
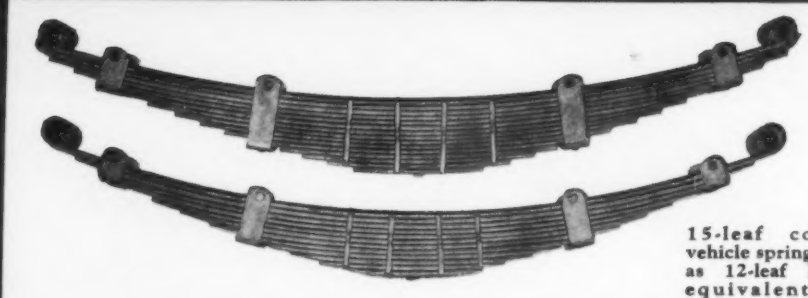
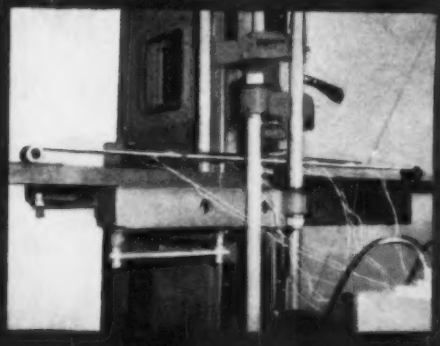




15-leaf commercial vehicle spring redesigned as 12-leaf Featherlight equivalent without increase in maximum stress.



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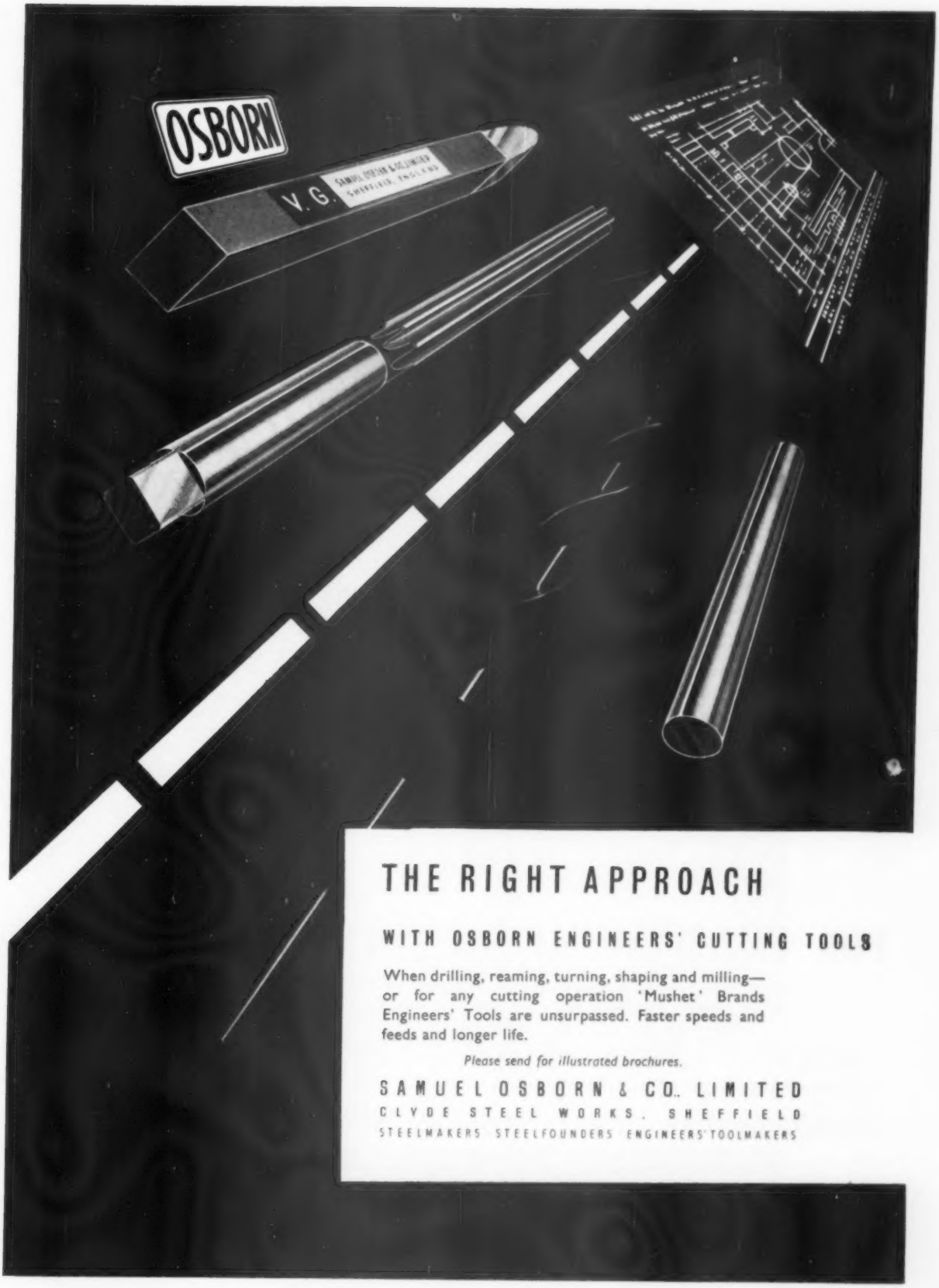

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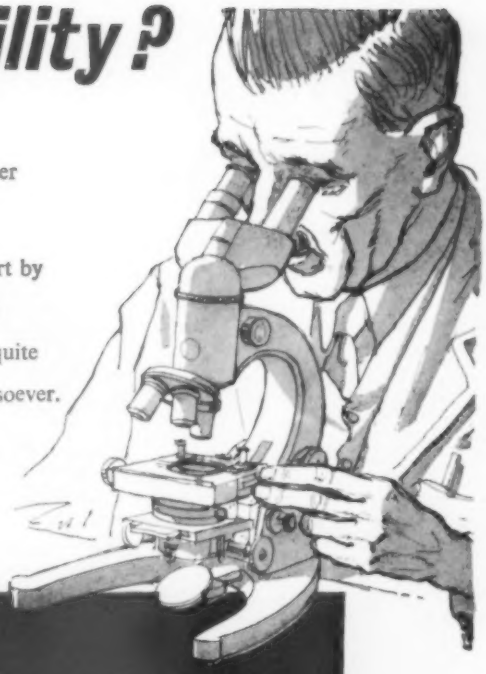
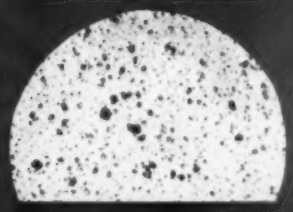
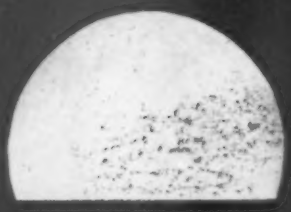


STABLE



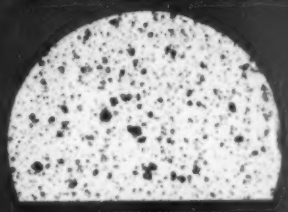
1 Fuel laden with abrasive dust, before filtration

2 The same fuel after passing through a C.A.V. paper element filter at beginning of test

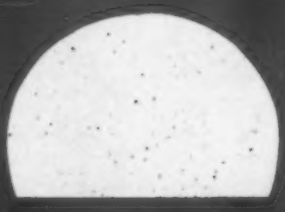


3 Fuel after filtration by the same element when all but choked by waxy sludge and dirt

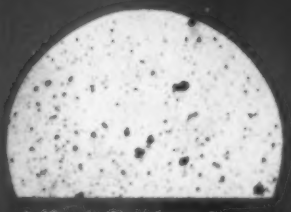
UNSTABLE



4 The same fuel is used for this test



5 At the beginning of test, filtration is fairly efficient



6 After the filter element is partly choked, the fuel passing through takes with it nearly all the particles of dust

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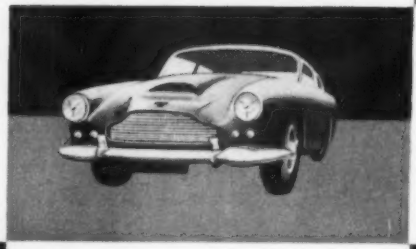

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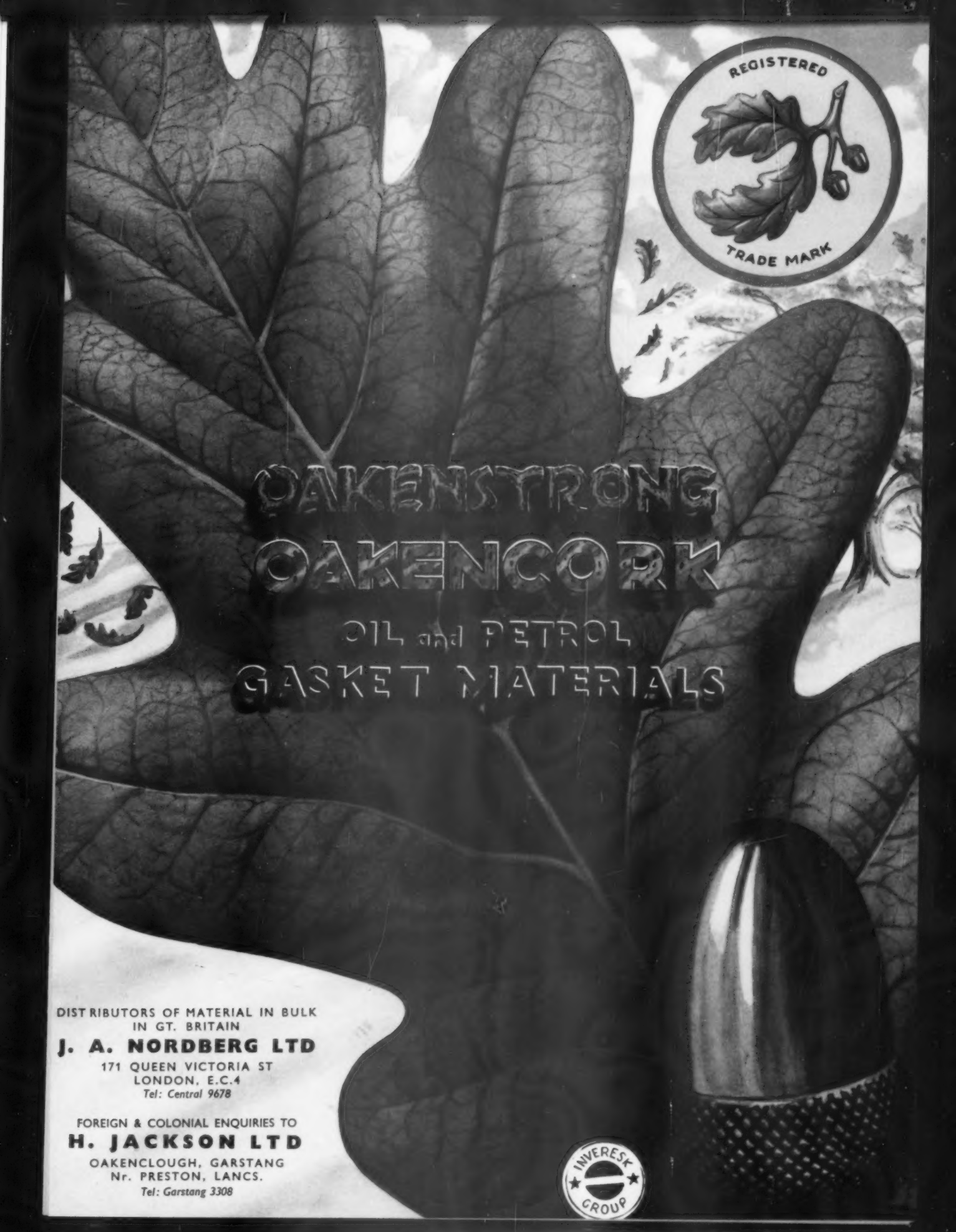

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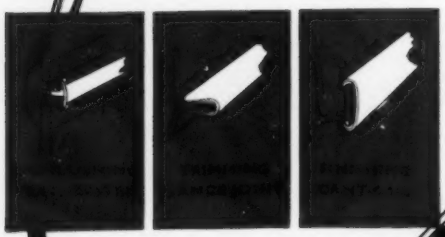

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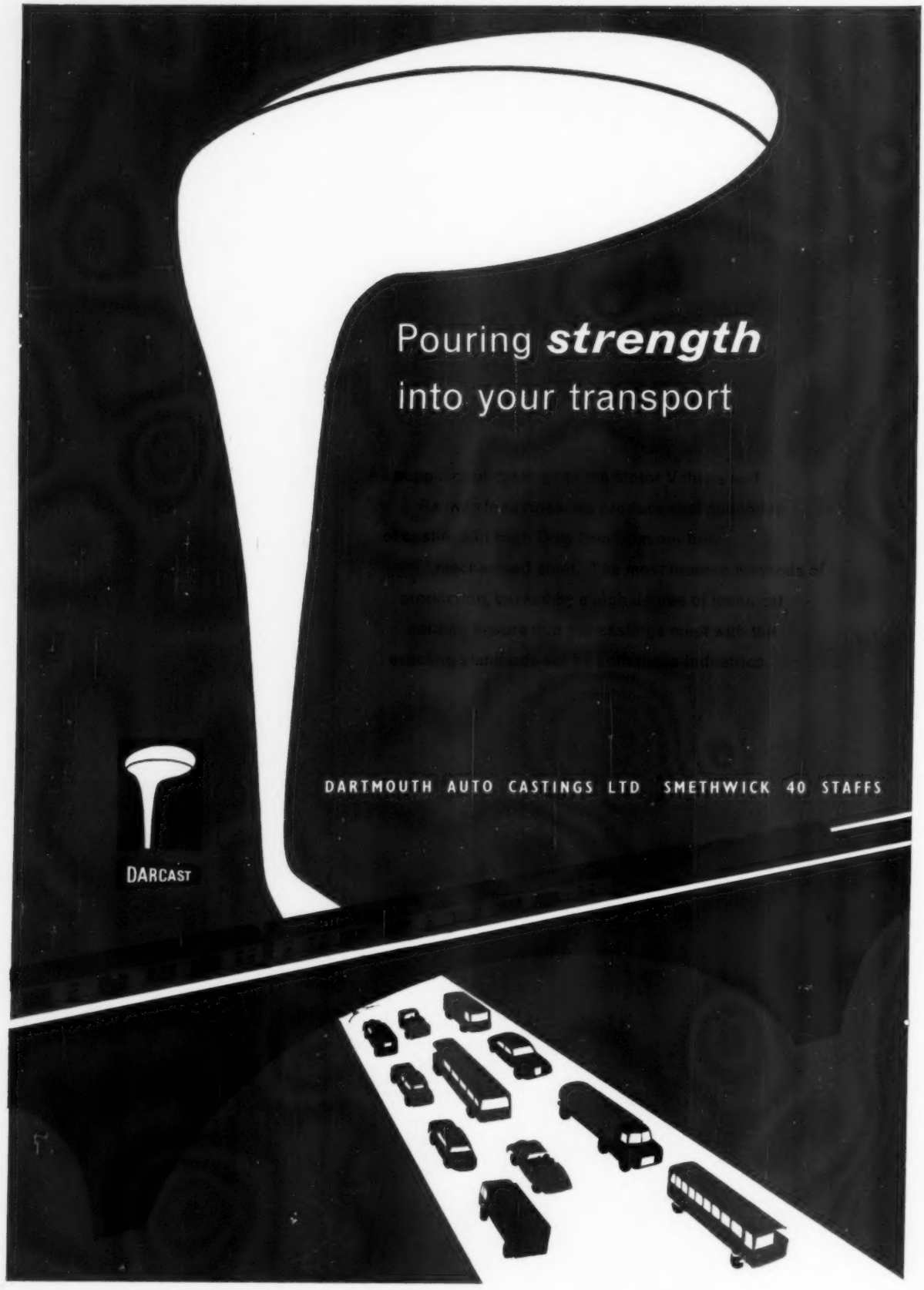
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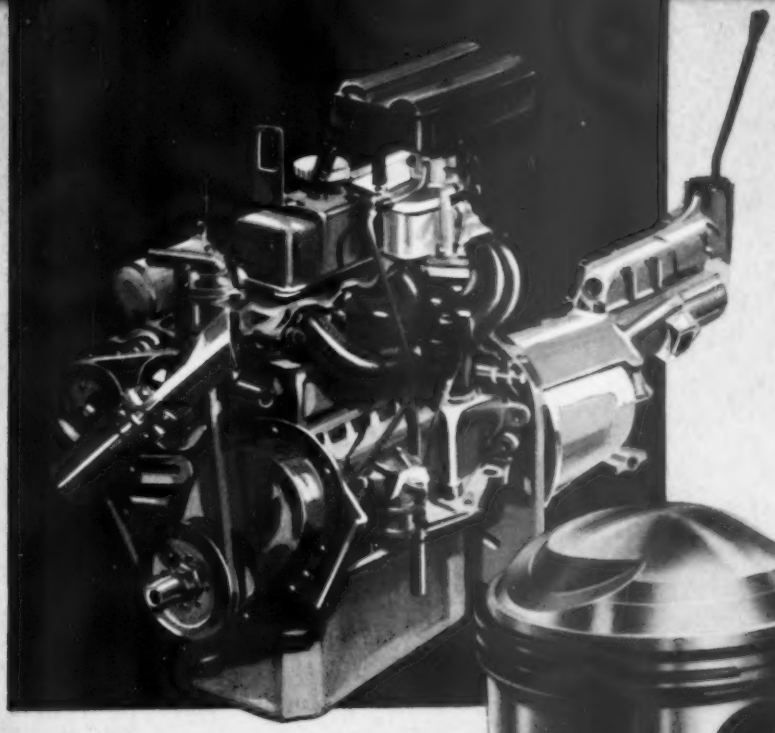

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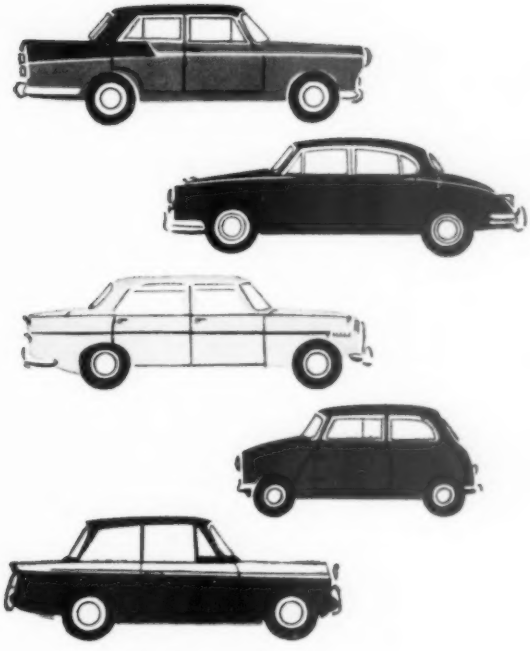

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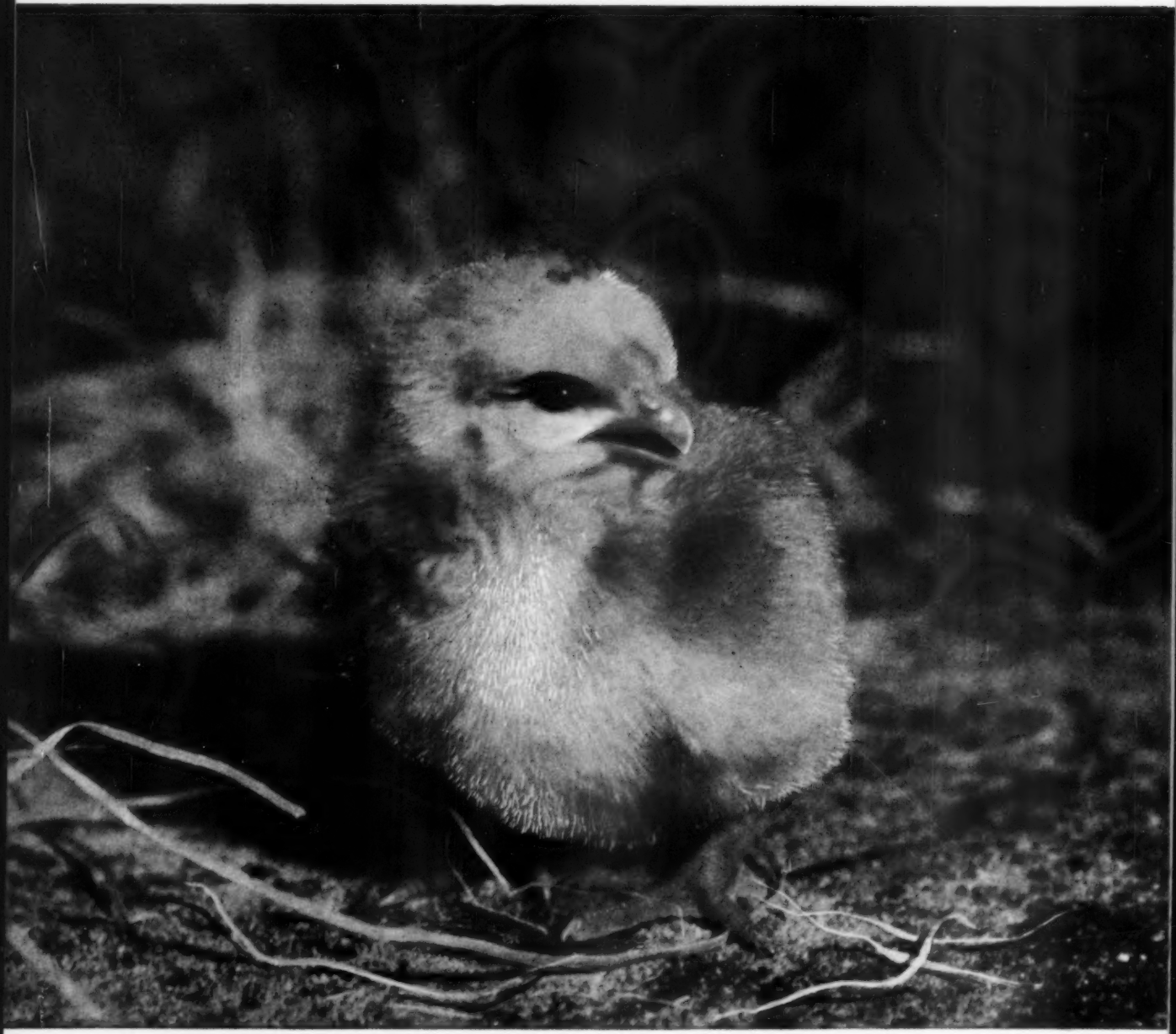

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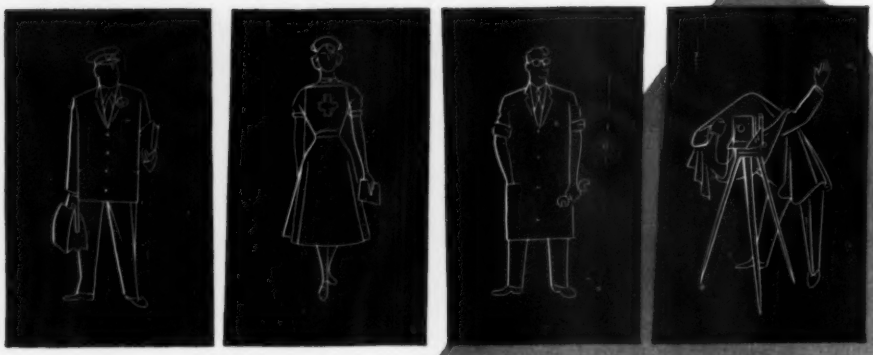

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Commercial Vehicle Brakes

IN our leader in February 1959 it was suggested that brake performance of commercial vehicles, particularly those in the heavy class, was in general inadequate under modern conditions of operation. Improvements have been made, but further progress is still needed. On most eight-wheel vehicles, braking equipment on all the wheels is available at least as an optional extra, and in some instances is standard. It is desirable, however, that all vehicles be so fitted, not only for operation on the improved road systems now being built but also to cater for conditions experienced in adverse weather.

It must be agreed that the practice of fitting braking equipment to only one pair of the front four wheels is desirable, especially as the weight transfer to the front wheels may more than double the static loading on them. Logically, use should be made of this extra loading, to improve overall braking efficiency. Another factor that is not always taken into consideration is that, with the transfer of load, the rear wheels are liable to hop and to tramp, and this further impairs the braking at the rear.

Road tests carried out by our sister journal *Motor Transport* have demonstrated that a certain eight-wheel vehicle with six wheel-brakes can be stopped in 78 ft from 30 m.p.h—equivalent to a mean retardation of 0·39 g—whereas another of the same type, but with eight wheel-brakes, was stopped in 52 ft—a mean retardation of 0·58 g. These tests were undertaken respectively two years and one year ago; even since then, advances have been made, and a maximum retardation figure of 0·8 g is now frequently attained with vehicles of the latest designs. There should not be too much difficulty in effecting further improvements to bring the mean retardation figures obtainable up to a value closer to the maximum.

In general, trucks of 7 to 8 tons capacity now tend to be the poorest so far as braking efficiency is concerned. One reason is that, with this type, competition is keenest in respect of low initial cost, and in the interests of economy, manufacturers are therefore tempted to sacrifice braking efficiency. However, the braking capacities of the various types of vehicle operating together on the roads differ appreciably, and obviously this situation cannot continue indefinitely.

Already at least one manufacturer of a range of trucks in the medium weight class has established a precedent that others cannot ignore: independent tests of five trucks of this range have demonstrated that mean retardation figures of about 0·7 g can be obtained. An essential requirement again is that the front brakes be adequate to take an appropriate proportion of the load —in this connection, account should be taken of not only the effect of weight transfer but also the fact that, in the unladen condition, even the static loading alone on the front wheels may be as much as twice that on the rear ones. For the avoidance of difficulties arising from premature fade with drum type brakes, lining areas of at least 50 in^2/ton, and preferably 60 in^2/ton, should be specified.

On many articulated vehicles, weight distribution in the laden condition could be improved. The keys to success are the attainment of better distribution of braking effort and reduction of the delay period in the operation of the power assistance. Improvement in suspension systems would of course also help and, in particular, attention should be directed towards increasing the roll resistance of automatic couplings, so that the stiffness of the rear suspension of the trailer can be reduced. Another problem—which, incidentally, applies also to every type of commercial vehicle—is the avoidance of excessive fierceness of the brakes in the unladen condition of the vehicle.

The more effective the brakes the greater, of course, is the amount of heat to be dissipated. This, because of the shrouding effect of the twin wheels on each side at the rear, is yet another argument for the fitting of more powerful brakes at the front. The current trend towards the employment of wheels of smaller diameter is of course accentuating the difficulties in respect of heat dissipation.

Disc brakes, provided their temperatures—and therefore rates of wear—can be kept down to acceptable levels, obviously will come into use on commercial vehicles. They offer a considerable advantage in respect of ease of servicing but a disadvantage so far as adaptation for handbrake operation is concerned. The latter problem, however, is not insurmountable. It will not be difficult to fit brakes of this type to vehicles that already have transmission handbrakes. Disc brakes currently offered for cars will obviously be used in light commercial vehicles, and when sufficient experience has been gained in these fields, operators of heavier vehicles will feel able to accept them with more confidence.

Dennis Loline Developments

Numerous Improvements to an Interesting Double-Deck Bus Chassis Include a New Gearbox and the Standardization of Air Suspension System at the Rear

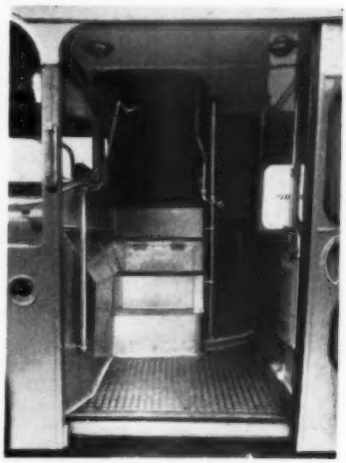
ONE of the difficulties encountered in designing a double-deck bus is, of course, to combine a low overall height, for operational versatility, with an acceptable degree of convenience for the passengers. In the Loline chassis, Dennis Bros. Ltd, of Guildford, can justifiably claim to offer a thoroughly satisfactory reconciliation of these conflicting requirements. This chassis is, of course, based on the Lodekka design, of Bristol Commercial Vehicles Ltd, the development of which was described in the May 1959 issue of *Automobile Engineer*. The first Loline model, exhibited at the 1956 Commercial Vehicle Show, was generally similar to the original Flat Floor Lodekka chassis, and had the same single-step rear entrance, with a slight ramp from the platform to the gangway of the lower saloon.

Two years later, Dennis Bros. exhibited a second version, which had a two-step forward entrance, made possible by modifications to the left-hand side member of the chassis frame; this version, too, had as its basis the corresponding Lodekka design evolved in 1957. It will be recalled that the third stage of development by B.C.V. was the forward-entrance model having only a single step, again with a slight ramp to gangway level. The latest Loline bus, shown at the 1960 exhibition and available in 27 ft 8 in, 29 ft 3 in and 30 ft long forms, is the Dennis interpretation of this single-step design. However, although the resemblance to the Lodekka is superficially still strong, the Loline III differs in more respects from the B.C.V. design than did either of the previous layouts, and it does not embody any components entirely manufactured by the Bristol company. Where Bristol castings and forgings are used, they are machined by Dennis Bros. In such a case as this, divergences of technical opinion are to be expected as development continues at both companies, and several interesting comparisons can be drawn between the respective methods employed.

The rather heavy appearance of the front end of the earlier Loline model has been ameliorated on the latest version by shortening the skirt of the frontal panel by 4 in, a change that has also improved the oil cooling. This panel, which is moulded of polyester-glass material, is in fact of three-piece construction, and the mid-portion—containing the radiator grille—is detachable. The mouldings are unstressed, the necessary strength being provided by a fabricated steel bridge member, anchored to the wings and the bonnet side in the cab. Since the radiator is carried on this bridge member, to which it is attached by four bolts on each side, it has no direct contact with the chassis.

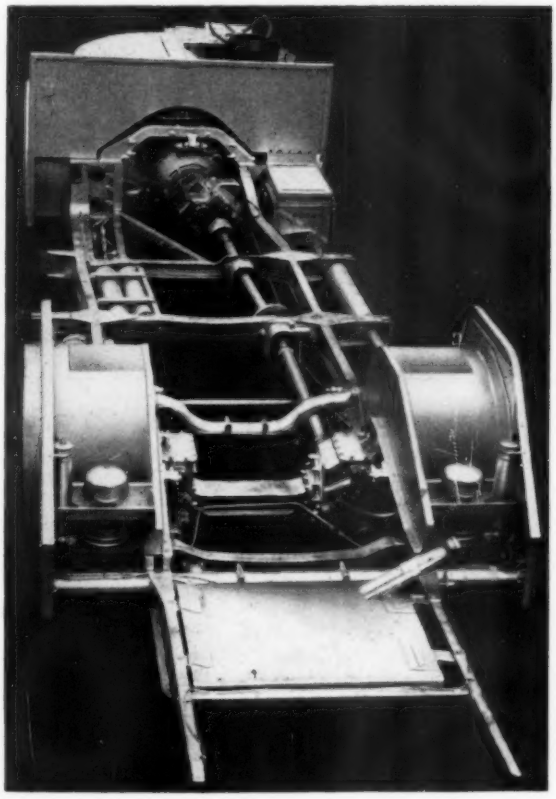
The bonnet lid, which is hinged to the engine cowling panel beside the driver, is also of polyester-glass construction, whereas steel was originally used. To combine rigidity with low weight, the lid is of the double-skin type, the two mouldings being bonded together after curing. The inner skin embodies cruciform stiffening ribs of channel section, and the peripheries of both mouldings are lipped. This construction, gives a smooth surface on each side of the lid and is claimed to result in a component weighing only half as much as a metal lid of equivalent strength. On production Loline chassis, the lid is counterbalanced to avoid the need for a stay.

In comparison with the earlier models, the bonnet of the



The entrance of the Luton Corporation bus depicted on the next page: the single step has a height of only 14½ in, or about 10 in above an average kerb

Below: In this rear view of the Loline III chassis, the modified wheel arch structures and the extensions of the frame behind the rear cross member are clearly visible. The battery now occupies the position, beside the gearbox, formerly occupied by the tank



A Loline III forward-entrance bus, equipped with coachwork by East Lancashire Coach Builders Ltd, as supplied to the Luton Corporation. This example does not have the shallower frontal panel now fitted as standard

Loline III is slightly shorter, to enable an oblique window to be installed ahead of the entrance, which is thereby made more clearly visible to the driver. Strength has been increased and weight saved by integrating the side structure on the left of the engine with the body and dash, instead of bolting it directly to the chassis: this structure includes the wheel arch, wing and bonnet side. By virtue of this alteration, the space around the engine has been increased and, consequently, accessibility for servicing operations improved.

To facilitate cleaning of the driver's cab, the floor is now flat, instead of having a shallow foot well. The draught proofing of the cab has been improved, and the instrument panel has been moved from its original rather low position to the right of the driver, to a site immediately in front of him, below the bottom rail of the windscreen. Under the instrument panel is the cab heating and demisting equipment. Visibility to the nearside has been enhanced by lowering the wing crown 2 in; a corresponding 1 in lowering of the offside wing has made it easier for the driver to get in and out.

It will be recalled that, on the B.C.V. Lodekka, a single-step forward entrance was obtained by means of a special left-hand side member for the frame. This member is virtually straight in plan view, but in side elevation it has a dip to accommodate the entrance platform, and turns upward in front of this dip, immediately behind the front wheel. A second channel pressing, mounted back to back with the main member and welded thereto, reinforces that portion of it ahead of the cross member immediately to the rear of the dip. From this cross member, an auxiliary side member, cranked in side elevation, extends forward to the front of the vehicle and forms the left-hand support for the power unit. On the Lodekka, this auxiliary member is connected to the main side member by a short tube, of large diameter and carrying a welded-on flange at each end.

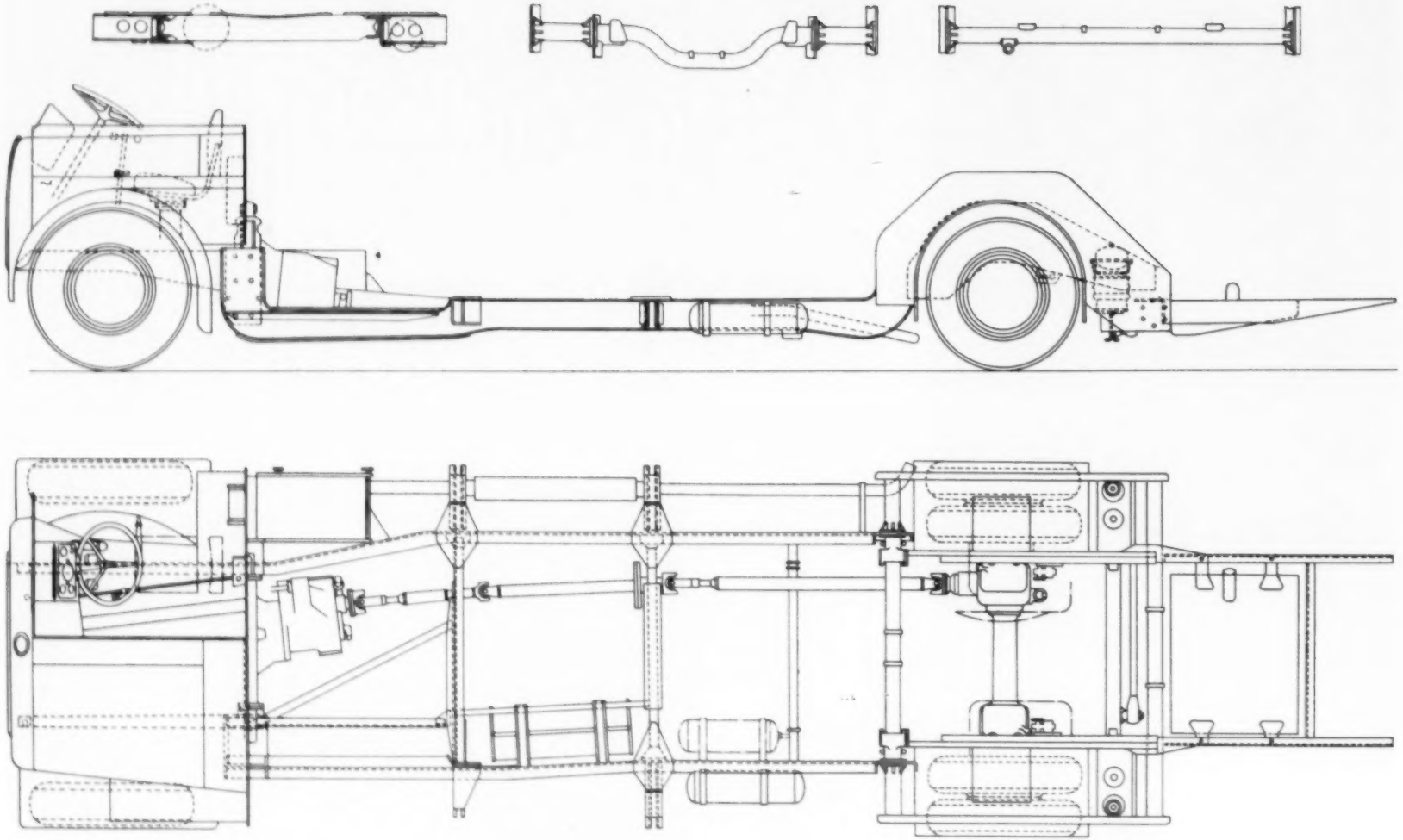
The Dennis engineers considered that the structural strength in this region might with advantage be increased. Though they have retained the basic idea of the main and auxiliary members, they have modified the layout in the following way. The length of the upswept leading end of the reinforced main member has been increased by 6 in, and the connecting tube has been replaced by a substantial fabricated box member. This box member can be seen in one of the accompanying illustrations. In addition to forming a bridge between the two longitudinals, it serves as a support for the body and as an anchorage for the arched cross member carrying the rear end of the power unit.

In other respects the portion of the frame of the Loline III ahead of the rear wheel arches closely resembles that of the Lodekka. On both types of chassis, each side member terminates in a vertical upsweep, and the ends are bridged by a tubular cross member. Because of the low floor level, the mid-portion of the cross member has a substantial dip. In each case, the basis of the wheel arch structure is an inboard and an outboard member; both members are flanged pressings and their rear ends are bolted to the tubular rear cross member of the frame. Ahead of the wheel, the inboard pressing is bolted to the main frame whereas the other is attached to the flanged end of a tubular extension of the dipped cross member.

The method of completing the wheel arch structure, however, varies markedly between the two vehicles. In the Lodekka layout, the two pressings on each side are connected only by two intermediate cross members. If air suspension is fitted, the more rearward of these members forms the fixed abutment for the air spring. The curved top panels, of the wheel boxes are separate, being incorporated in the body. On the latest Loline, in contrast, these panels—which are made from 12 s.w.g. steel—are welded to the longitudinal pressings, and project beyond the outboard ones. Although the second cross member between each pair of pressings is retained, the other has, of course, been deleted.

A characteristic of all the Flat Floor Lodekka models is the absence of any rearward extensions of the frame behind the wheel arches, and this layout was continued on the first two Loline designs. In cases where a rear-entrance body is fitted, the body structure—which is integrated with the frame on both makes—is reinforced to provide the necessary strength at the platform. However, to give the body builder greater scope in the treatment of the rear end, Dennis Bros. have reverted to the fitting of frame extensions, of the bolted-on type. The method of attachment is illustrated.

Before leaving the frame, mention must be made of an important difference between the policies of the two companies. The special left-hand side member of the frame is employed by B.C.V. only on forward-entrance chassis: where a rear-entrance body is to be fitted, a conventional, upswept side member is used, which is virtually the mirror image of the right-hand component. In the interest



REPRODUCTION OF THE GENERAL ARRANGEMENT DRAWING OF THE DENNIS LOLINE III CHASSIS WITH 19 FT 2 IN WHEELBASE

The three cross members shown above the side elevation are, from right to left, those immediately behind and in front of the rear wheels, and that carrying the second bearing of the three-piece propeller shaft

of standardization, however, all Loline III chassis—irrespective of the position of the entrance—have the frame layout described. The only difference between the frame of a front-entrance and a rear-entrance vehicle is that in the latter case the rear extensions are more robust, to cater for the increased loading involved.

A wide choice of engines is available to suit different conditions of operation, but the most popular are the Gardner 5LW, 6LW and 6LX units, the power outputs of which are respectively 94, 112 and 150 b.h.p. There is nothing unorthodox about the engine installation but a few details are worthy of mention. A Purolator paper element air filter is now standard equipment, as also is an air compressor of increased output—10 ft³/min, as compared with the former 7 ft³/min. The compressor unloader and safety valve, and its filter, are now installed in the engine compartment, and not in the cab. As soon as supplies become available, an a.c. generator will be offered as an optional extra. It is the C.A.V. AC7 unit, with transistorized rectifier and control panel, and it is driven at 2·4 times engine speed to ensure an adequate charge rate at idling speeds.

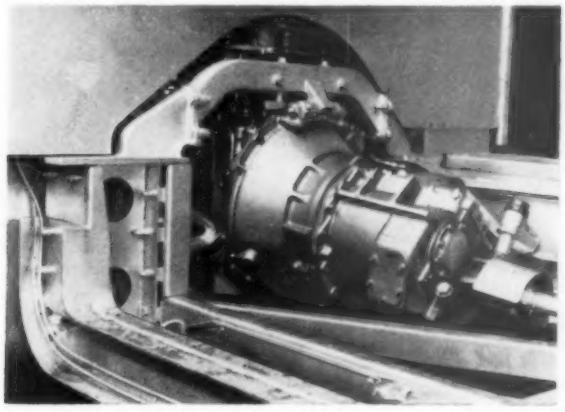
As before, there is the choice between a Dennis four- or five-speed constant-mesh gearbox and a Self-Changing Gears RV28, pneumatically operated semi-automatic transmission, incorporating one of the new combined fluid coupling and centrifugal clutch units. In the case of the manual transmission, however, considerable modification has been made. Instead of the 14 in diameter two-plate clutch, a 16 in diameter single-plate clutch of Dennis design is now employed. So that the life of the clutch between overhauls will be equal to that of the engine, the thickness of the friction facing is three times what it was on the plates of the earlier clutch. The new clutch embodies the forced draught centrifugal cooling system mentioned in the November 1960 issue of *Automobile Engineer*. It is stated that the air flow through the bell housing amounts to 500 ft³/min at idling speed and 2,000 ft³/min at maximum r.p.m, so the cooling effect should be considerable.

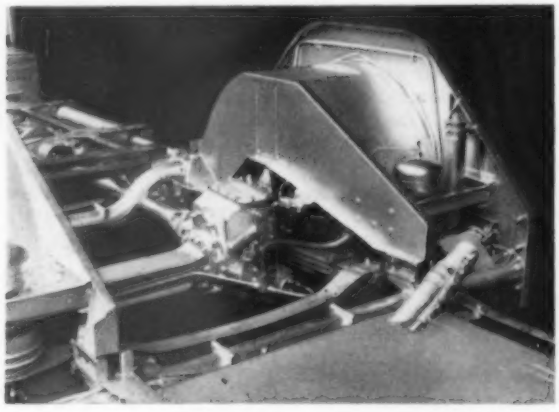
An entirely new gearbox, the V type unit, is fitted to the Loline III; it is not only of greater torque capacity but is of improved design and appearance. The earlier box was satisfactory for use with engines having a continuous torque output of up to 370 lb-ft, but it was felt that it would be over-stressed by the 485 lb-ft maximum torque of the Gardner 6LX engine, which had become available after the introduction of the Loline II chassis. Since the V type gearbox is stressed for a continuous torque input of 500 lb-ft, it will be operating well within its limits with the 6LX unit. Consequently, it also should have an overhaul life equal to that of the engine.

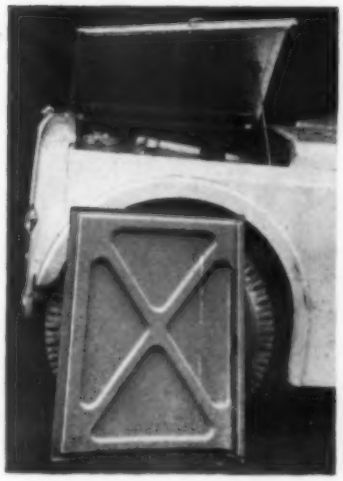
A general arrangement drawing of the five-speed version of the gearbox is reproduced on these pages. The unit, which is of the all-indirect type, with all gears—including reverse—in constant-mesh, is compact and sturdy. It is noteworthy that, because all the rubbing surfaces on gears and shafts are Parco-Lubrized before assembly, it has not been found necessary to use needle roller bearings nor to have pressure lubrication; consequently, benefits in terms of production cost have been obtained. Dennis Bros. are in the process of standardizing this treatment for all their gearboxes and axles.

The gearbox has an aluminium casing, and the bearing housings are nodular iron castings, to provide the maximum security for the outer races. Ready access to the selector mechanism has been provided by mounting this above the gear clusters. The casing is dowelled and bolted to the bell housing and, when it is removed, the clutch withdrawal mechanism comes away with it without disturbing the clutch itself, thereby facilitating servicing. As can be seen from the illustration of the gearbox, alternative reverse idlers are available. One of these provides a higher ratio than the other

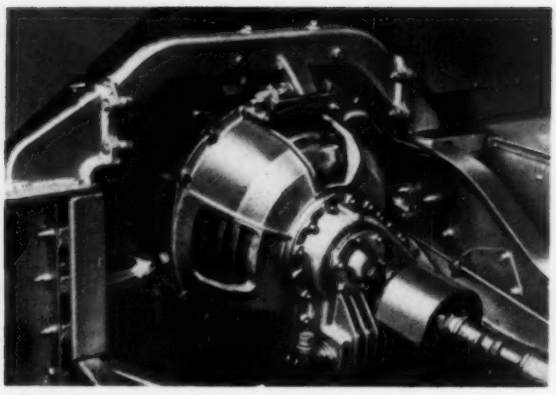
Left: The bridge between the front of the left-hand side member and the auxiliary member has been reinforced. This view also shows the new V type gearbox and the air intake and outlet openings for the clutch cooling system. Right: General view of the rear axle and the air suspension system

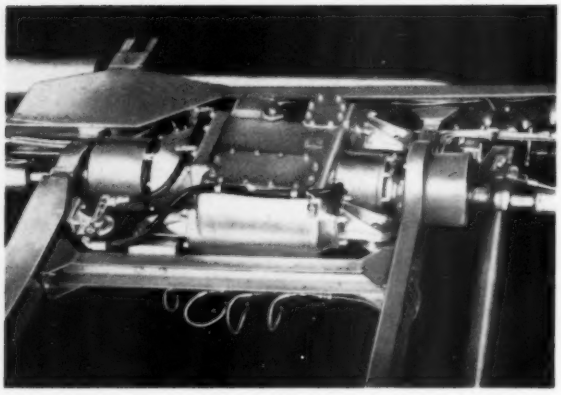






The latest bonnet lid is a double-skinned plastics moulding; it is both lighter and much more rigid than the steel lid that is fitted to the chassis in this illustration



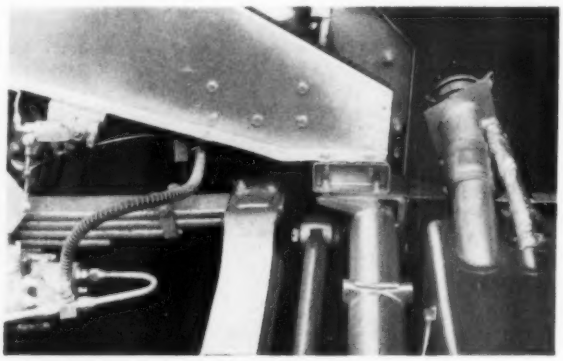


and is embodied, to avoid the transmission of excessive torque to the rear axle, when an engine of high output is fitted.

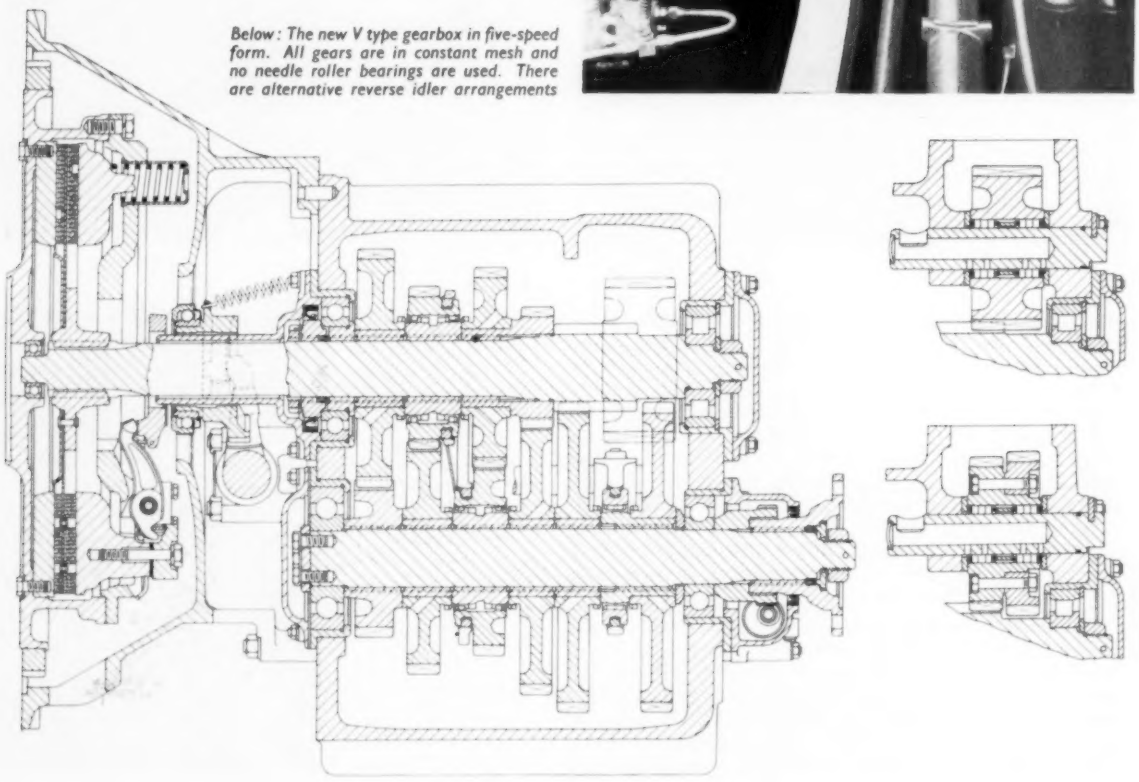
Where the S.C.G. transmission is specified instead of the standard type, the gearbox is remotely mounted on the right-hand side, in the third bay of the frame, behind the power unit. An additional cross member is fitted behind it to act as a rear bearer, and is longitudinally braced to the transverse member immediately ahead of the box. Whereas with the standard transmission there is a three-piece propeller shaft between the engine and rear axle, the semi-automatic gearbox is driven by a two-piece shaft and there is a relatively short, third shaft between it and the axle.

As on the Lodekka, the longitudinal axis of the engine is inclined laterally relative to that of the vehicle. The inclination is towards the right and is necessary to avoid excessive angularities in the propeller shaft, since the input to the rear

Above: The two assemblies that comprise the optional semi-automatic S.C.G. transmission. On the left is the combined fluid coupling and friction clutch unit, and on the right is the gearbox. Below: The rearward extensions of the frame are bolted to the rear cross member



Below: The new V type gearbox in five-speed form. All gears are in constant mesh and no needle roller bearings are used. There are alternative reverse idler arrangements



axle is well over toward the right-hand side of the vehicle. Though the internal parts are made by Dennis Bros, the Loline axle is basically the Lodekka unit, which was specially designed to permit a low floor level: it is of the double-reduction type and has a gear case at each side, connected at the bottom by a square-section, hollow beam containing the transverse shaft. In the right-hand gear case is the spiral-bevel primary reduction pair, which is combined with a differential in the orthodox manner, and a straight-tooth spur secondary reduction pair of gears. A short, splined shaft transmits the drive from the secondary output gear to the wheel hub. The transverse shaft drives a similar secondary reduction in the left-hand gear case. Among the modifications made to the axle by Dennis Bros. are the fitting of heavier-duty bearings for the crown wheel and pinion, and the strengthening of the bearing mountings for the spur gears.

Whereas air suspension at the rear is optional on the Lodekka, it is standard on the Loline III, though leaf springs are available to special order. The air suspension layout employed is identical on both makes of vehicle, except in minor respects such as pipe runs. Although the system was described in the Lodekka article mentioned earlier, a brief recapitulation here may be of assistance. Stiff semi-elliptic leaf springs are used to locate the axle longitudinally, and lateral location is effected by a panhard rod. B.C.V. adopted this layout because, in addition to its technical merits, it permitted a high degree of interchangeability between the components of the air and leaf springing systems.

At their leading ends, the leaf springs are anchored to the frame, and their rear ends are bolted to a transverse I-section beam, to which the panhard rod is attached. On this beam, immediately behind the wheels, are mounted the bases of the Andre rolling diaphragm type air springs. Adequate roll stiffness is provided by the combination of the wide spring base and the considerable resistance of the leaf springs to torsion. The suspension units have integral surge tanks, and the Clayton Dewandre direct-acting levelling valves are mounted, one on each side, between the wheel arch structures and the axle casing. Outboard of each spring unit is a Woodhead-Monroe telescopic damper.

For the beam type front axle, the same design of forging is used on the Loline as on the Lodekka, but it is machined by Dennis Bros. On the Loline III, the material of the king-pin bushes has been changed: it is now phosphor-bronze instead of hardened steel. This modification has resulted in a noticeable lightening of the steering, though it has been necessary to increase the bearing area to ensure adequate life.

On the earlier Loline chassis, the exhaust system was disposed inboard of the right-hand longitudinal member of the frame, as it is on the Lodekka. It now passes outboard of the side member, a change that has permitted a pipe of larger diameter to be employed when necessary; a 4 in diameter pipe is regarded as desirable, to avoid restriction in the system, for the Gardner 6LX engine. This change has been made possible by moving the air reservoirs and valves of the braking system from the right to the left side of the frame. Previously, the valves were installed outboard of the side member, under the forward mounted fuel tank then employed, in the first bay of the frame. They now occupy a position between the left-hand main and auxiliary side members, in the same bay.

Formerly, the independent reservoirs for the front and rear brake systems were mounted outboard of the side member, in the second bay; though still in this bay, they too are carried inboard, immediately behind the valves, on the Loline III. Air from the reservoir for the front brakes passes into the air suspension reservoir, which has also been moved to the left and is situated just outboard of the side member, in the third bay of the frame. Between the brake and suspension reservoirs is a restrictor valve, to reduce the pressure from the normal value of 110 lb/in² to the 70 lb/in² required for the suspension system. Should the pressure become too low in either brake reservoir, an automatic switch is operated that causes a buzzer to sound in the cab. If a pneumatic door operation mechanism is fitted to the vehicle, the reservoir for this is also installed to the left of the third bay of the frame, but inboard of the side member.

As a result of the incorporation of the frame rear extensions, the fuel tank has been transferred from its previous forward position—alongside the right-hand longitudinal member of the frame, behind the engine bulkhead—to a mounting between these extensions. Tanks of alternative shapes are fitted, according to whether the body has a forward or a rear entrance. In a forward-entrance vehicle, a tank of shallow wedge shape is employed; its lowest point, at the front, has adequate ground clearance for all normal operating conditions. A rear-entrance bus has a tank of uniform rectangular section, installed towards the offside, under the stairs. Both types of tank have a capacity of 34 gallons; they are well baffled internally, and are rubber mounted and externally braced to minimize damage in the event of a collision. All fuel pipes are now of plastics material.

On the Loline III, the standard position for the battery stowage is that formerly occupied by the fuel tank, as defined in the previous paragraph. With this stowage, a standard type of battery is used. However, should a customer require an under-seat mounting for any reason, this can be supplied, but a special low-height battery is then necessary. An automatic chassis lubrication system, of either Tecalemit or Clayton Dewandre manufacture, is standard equipment, whereas it was an optional extra on the earlier chassis.

According to the manufacturers, the Loline has the following major dimensions: wheelbase, 16 ft 11 in, 18 ft or 19 ft 2 in; front track, 6 ft 10 in; rear track, 6 ft 2⅞ in; body overall length (maximum), 27 ft 8 in, 29 ft 3 in or 30 ft; overall width, 7 ft 11½ in; overall height (standard), 13ft 5 in; step height, 14½ in from ground, 10 in from an average kerb. The chassis weights of the 27 ft 8 in and 30 ft versions, fitted with the Gardner 6LW engine and manual transmission, are 5 tons 3 qr and 5 tons 2 cwt 1 qr respectively, in either forward-entrance or rear-entrance forms.

Soviet Technology Digest

A MONTHLY publication, entitled "Soviet Technology Digest", has recently been introduced by Pergamon Press Ltd, of Headington Hill Hall, Oxford. Each issue comprises approximately 100 pages, and the annual subscription rate is £10. Full translations of any article included in the digest can be supplied within four weeks of an order being received by its publishers. The maximum charge for these translations, even when there is only a single applicant for the paper, is 70s per page of original. If the demand is great enough, the charge will be less. The digest is divided under the headings Design and Production; Metallurgy; Instruments and Automation; and General. Finally, there is a section devoted to additional contents lists of various publications.

Computer Exhibition

FROM 3rd to 12th October 1961 there will be an exhibition of electronic computers at Olympia, London. Indications so far show that emphasis will be placed at least as strongly on new applications as on new equipment. At the same time, the Business Computer Symposium will be held at Olympia on 4th, 5th and 6th October. Users from both large and small firms will speak of their experience with computers and will exchange information. Further details can be obtained from F. C. Pritchard, Wood and Partners Ltd, 197 Knightsbridge, London S.W.7, telephone number, Kensington 8151.

STOPPING FROM 100 M.P.H.

Performance of a Car Equipped with Disc Brakes

R. N. KEMP* A.F.R.Ae.S.

WORK done hitherto by the Road Research Laboratory on braking performance of vehicles has included the measurement of the minimum braking distances obtainable from speeds of up to 60 m.p.h. by cars fitted with conventional drum brakes. Now that both cars and roads are being designed to permit cruising speeds exceeding 60 m.p.h, disc brakes are becoming increasingly common and, as is well-known, are now standard equipment on several British cars capable of attaining speeds of 100 m.p.h. or more. Therefore, further tests have now been made by the Laboratory to find the minimum braking distances obtainable from speeds of up to 100 m.p.h, using a sports type car fitted with disc brakes.

Description of tests

The vehicle used was a 1957 standard production high performance car fitted with hydraulically operated, vacuum-assisted, self-adjusting disc brakes on all wheels. It was in excellent condition throughout, having completed only 3,000 miles of careful running since new. For the measurement of the braking distances, the shot method[1] was employed. With this method, as soon as the driver applies pressure to the brake pedal, an electrical contact is made and an electrically fused detonator fired to discharge a chalk pellet from a magazine on to the road, thus marking the point at which the brakes are applied. The distance from this mark on the road surface to the magazine when the vehicle has stopped is the braking distance.

During the tests, the speed of the car, just before the application of the brakes, was first obtained by measuring, with the stop-clock of a crystal oscillator-decade counter, the time taken for the front wheels to cross two pneumatic tubes placed 5 ft apart on the road surface. Then the driver applied the brakes as hard and as quickly as possible immediately after crossing the second tube. To give records of the deceleration-time curves when braking, a recording decelerometer was carried in the car. A series of tests were made by two drivers, both experienced in making brake tests, in a random order at speeds from 20 m.p.h. to 100 m.p.h, repeat runs being made at 30, 60 and 100 m.p.h. The tests were carried out on an aerodrome runway having a good surface; throughout the series, the surface was dry and there was no wind. No definite time interval between the tests was allowed for the brakes to cool, but usually a run was made every 3 to 5 minutes.

* *Road Research Laboratory, Department of Scientific and Industrial Research*

Results

The mean braking distances obtained in these tests were 47 ft from 30 m.p.h, 185 ft from 60 m.p.h. and 515 ft from 100 m.p.h, the mean overall deceleration being about 0·65g at all speeds: these results are given in the Table. There was no significant difference between the results obtained by the two drivers. From Fig. 1 it can be seen that the braking distances observed agreed fairly well at all speeds with those derived from the expression $S=0{\cdot}053V^2$, where S = the braking distance in ft, and V the initial speed in m.p.h, obtained from earlier tests[2] in which cars fitted with drum brakes were braked from initial speeds of up to 60 m.p.h. This expression implies a mean overall deceleration of 0·63g. Closer agreement was obtained for the disc brakes, by using the expression $S=0{\cdot}0515V^2$.

Although no results appear to have been published showing the effect of brake fade on the braking distances obtainable in emergency braking from high speeds, using drum brakes, earlier tests by the Laboratory[2] and others in America[3], in which cars were braked from speeds up to 90 m.p.h, showed that if, at higher speeds, the wheels were not locked immediately on applying the brake pedal, it was impossible to lock them at all, because of brake fade. Other investigations[4]

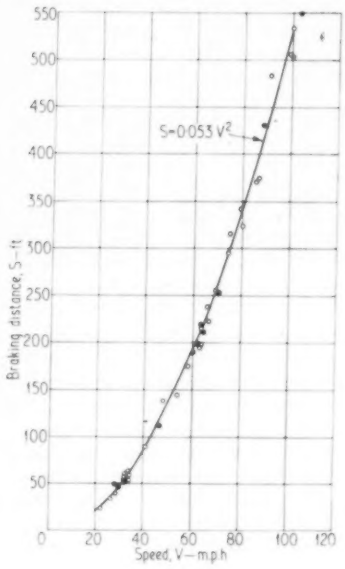


Fig. 1. Braking distances from different speeds of a car fitted with disc type brakes
● *driver A;* ○ *driver B*

Table—BRAKING PERFORMANCE, FROM DIFFERENT SPEEDS ON A DRY SURFACE, OF A CAR FITTED WITH DISC BRAKES

Driver	*Speed m.p.h.*	*Number of stops*	*Mean braking distance, ft*	*Mean maximum deceleration, per cent g*	*Mean overall deceleration, per cent g*	*Standard deviation of braking distance, ft*
A	30	4	46	80	65	5
	60	4	187	79	65	6
	100	2	508	76	65	—
B	30	4	47	81	64	6
	60	4	183	80	66	7
	100	3	518	82	65	—
Mean of both drivers	30	8	47	—	64	5
	60	8	185	—	65	7
	100	5	514	—	65	10

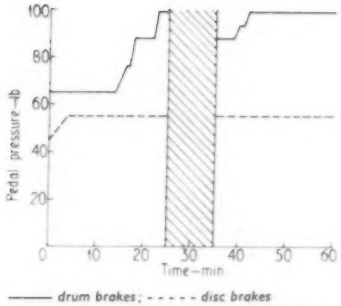


Fig. 2. Above: Typical results of fade tests with disc and drum type brakes—all stops were made from 50 m.p.h. at a retardation of 16 ft/sec², at intervals of one minute.[5] The shaded area represents the periods with the vehicles stopped and the handbrakes on

Fig. 4. Below: Deceleration-time curves for a car with disc brakes stopped from high speeds. The upper of the two diagrams is for the condition with two front wheels locked, and the lower one for that which is obtained when none of the wheels is locked

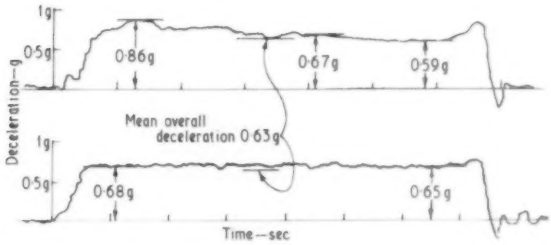
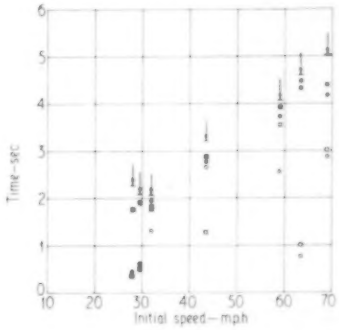


Fig. 5. Right: Comparison of tyre wear on the off-side rear tyre, left, and the near-side front tyre, right, the former locking and the latter not doing so during the test

Fig. 3. Below: Time taken from the application of the brakes to the locking of the wheels of a car equipped with disc brakes

○ near-side front; □ near-side rear; ● off-side front; ■ offside-side rear; ½ duration of braking



into the fade characteristics of drum brake linings have shown that reductions of over 30 per cent in the average overall deceleration obtained for a given pedal pressure can occur when brake drum temperatures attain 300 deg C, a temperature that can be reached in a 0·47g stop from 60 m.p.h.[5]

In the tests with disc brakes, no appreciable fade could be detected. This is in agreement with results obtained by Bradbury and Parnell[6], who showed that, while with drum brakes the pedal pressure required to obtain a deceleration of 0·5g, 16 ft/sec², in repeated brake applications increased from 65-100 lb, the pedal pressure with disc brakes remained constant, apart from an initial increase of 10 lb, Fig. 2.

Films taken of the wheels during these braking tests showed that it was not possible to lock all wheels simultaneously, Fig. 3: this was probably owing to slight differences in the coefficient of friction between the brake pads and discs of the different wheels, and in the pressure at the brake pads—which have no self-energizing characteristics—being only just sufficient on this surface to lock those with the higher frictional values. When the car was stopped from speeds of over 40 m.p.h, locking of the wheels occurred more often in the later stages of braking than at the beginning. The deceleration-time curves also showed that when the vehicle was braked from 100 m.p.h, with none of the wheels locked, that is, when brake fade might be expected owing to heating of the brake friction surfaces, the deceleration of the car remained sensibly constant, but when at least two of the wheels locked, the deceleration fell continuously from the initial peak value occurring immediately before the wheels locked. The deceleration-time curves in Fig. 4 illustrate this, the deceleration falling when two front wheels were locked from a peak value of 0·86g to 0·65g. Evidently there was a falling off in the frictional force between the surface of the tyre and road, probably owing to temperature rise in the contact area and consequent changes in the physical properties of the rubber, perhaps due to melting. From this it might be concluded that longer braking distances would have been obtained had all four wheels locked.

Damage to tyres in a locked wheel stop from a high speed on a dry surface with a high coefficient can be severe. In Fig. 5, the nearside front tyre of the car used in the tests, which locked frequently, is compared with that of the offside rear wheel, which usually did not lock; both tyres were in a similar almost new condition before the tests. The marked area on the nearside front tyre shows the wear that occurred over the contact area in one stop from 100 m.p.h. when the wheel was locked for the last 300 ft; in the central area the marks are of cuts which penetrated to the tyre cords. This indicates one of the potential values of an anti-skid device such as the Maxaret braking system[7] in which maximum braking without wheel locking can be achieved.

Conclusions

It has been shown in previous papers that drum brakes, as fitted to most cars, give an overall mean deceleration of 0·63g when braked from speeds up to 60 m.p.h. Beyond 60 m.p.h, fade begins to be important, and the overall deceleration may fall. On this particular car fitted with disc brakes, the mean overall deceleration was 0·65g when braked from all speeds up to 100 m.p.h, without fade.

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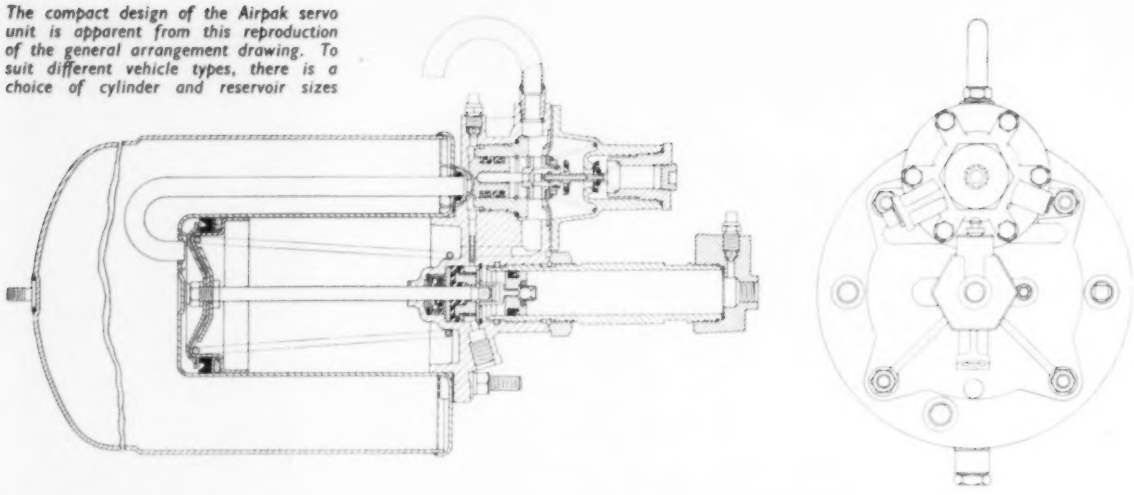
The compact design of the Airpak servo unit is apparent from this reproduction of the general arrangement drawing. To suit different vehicle types, there is a choice of cylinder and reservoir sizes



Improved Servo Braking Equipment

Details of the Clayton Dewandre Reservoir Type Airpak Air-Hydraulic Servo Unit, and the S.C.4 Air Compressor

FOR commercial and public service vehicles on which brake servo assistance by compressed air, rather than vacuum, is required, a new two-unit system has been put into production by the Clayton Dewandre Co. Ltd, Titanic Works, Lincoln. It comprises a compact, reservoir type servo unit, known as Airpak, and one of the company's latest compressors, which has the designation S.C.4. These two units are designed for use together as a compressed air operated system alternative to the familiar vacuum operated Hydrovac servo with the appropriate exhauster.

The Airpak assembly comprises four units: they are the air cylinder and power piston, the air pressure reservoir, the hydraulically actuated control valve, and the hydraulic output cylinder and piston. Three basic sizes of unit are manufactured. The major difference between the three is the diameter of the air servo cylinder, which is 3, 4 or 4½ in. In each case, the hydraulic output cylinder can have a diameter of 1, 1⅛ or 1¼ in, to suit the requirements of the vehicle concerned. The diameter of the integral air reservoir is 8½ in on all three versions, but the length—and hence the capacity—is greater on the 4½ in model than on the other two. Reservoir capacities of 550, 520 and 820 in³ respectively are specified for the three sizes. Although the standard range of units is designed for use with vegetable base fluid, a separate range is available that is suitable for operation with mineral base fluid. The latter is for installations the design of which is such that unusually high temperatures are experienced and a vegetable type therefore liable to boil. Consequently, there are two different types of seal, one of synthetic and the other of natural rubber. The manufacturers stress, therefore, the importance of ensuring that the seals used are appropriate to the fluid to be employed in the system.

The air cylinder is mounted coaxially within the pressure reservoir, and both components are steel pressings. Pressings are used also in the construction of the power piston, the crown of which is concave to increase its rigidity. A lipped sealing ring of synthetic rubber fits in a circumferential groove in the piston skirt assembly. The piston is rigidly attached to one end of a push rod, the other end of which projects through a seal in the end cover. The cover is a light alloy diecasting. A helical return-spring is interposed between the piston and the end cover.

The hydraulic cylinder is coaxial with the air cylinder. It consists of a tube screwed into the end cover and secured by a lock nut. On to its outer end is screwed a cap that embodies a bleed screw and the outlet port to the wheel cylinders. The hydraulic piston is pin-jointed to the free end of the push rod of the power piston, and is machined to receive a check-valve, of the spring-loaded ball type. This valve is actuated—as will be explained later—by a yoke, the stem of which projects through the hydraulic piston.

There is an external pipe to connect the pedal operated master cylinder to a union on the end cover; an oblique passage in the cover leads from the union to the annular chamber around the end of the push rod. From this space, a second internal passage leads through a restrictor to a control valve, the piston of which operates in a steel sleeve housed in a bore in the end cover. In the control valve piston, at the end remote from the hydraulic supply, is a blind axial hole, into which fits a rod projecting from the centre-piece of a diaphragm assembly. This assembly is coaxially in tandem with the piston. The periphery of the diaphragm is clamped between the facing on the end cover and the diecast body that houses the atmospheric and the compressed air valves. This control valve body is secured to the end cover by setscrews, with washers.

A conical spring biases the diaphragm assembly towards the valve piston. The valve assembly, comprising an atmospheric valve and a two-stage compressed air inlet valve on a flexible stem, is held in position by a smaller conical spring in the control-valve body. A seat for the atmospheric valve is formed on the diaphragm centre-piece. The second-stage portion of the two-stage inlet valve has its seating in the control valve body and, in turn, provides the seat for the first-stage valve. This two-stage arrangement has been

adopted to permit the control valve to be actuated, in normal braking, by relatively low hydraulic pressure, whilst providing for the rapid admission of air to the power cylinder when heavy braking is needed in an emergency.

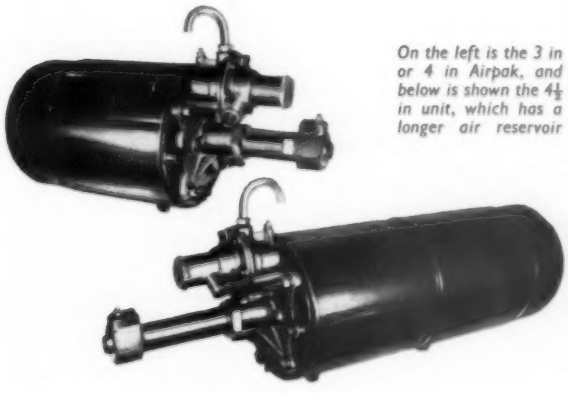
Passages in the end cover and valve body connect the air reservoir to the portion of the valve body beyond the compressed air valve. The chamber between this valve and the diaphragm is connected by what is termed the control tube and by a passage in the end cover to the opposite end of the power cylinder. Air displaced from the air cylinder by movement of the power piston passes into the portion of the control valve chamber between the diaphragm and the control valve piston, and this portion is vented to atmosphere. When the atmospheric valve is open, the chamber between the valve and the diaphragm is in communication, through the centre-piece, with atmosphere.

Operation

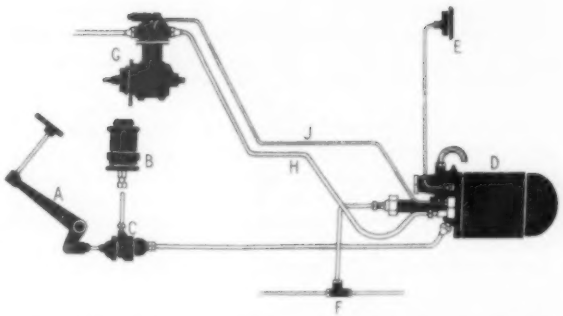
The sequence of operations is shown in the accompanying diagrammatic illustrations. In the "brakes released" position of the Airpak unit, the control valve piston and diaphragm are biased to the left by the diaphragm spring. Both compressed air valves are seated, by the combination of air pressure and the action of the poppet return spring, and the atmospheric valve is open, so both sides of the diaphragm are at atmospheric pressure. Since, as a result, there is no pressure differential across the power piston, this is held at the left-hand end of the cylinder by its return spring, and the hydraulic piston is against its stop.

An indentation on the end of the power cylinder, and a washer in the end cover, form stops for the "off" positions of the pistons. Because of the axial float of the yoke within the hydraulic piston, its stem then holds the ball of the check-valve off its seat, to permit fluid to pass from one side of the hydraulic piston to the other; it follows that the reservoir of the master cylinder can absorb any changes in the volume of the fluid caused by variations in temperature. This situation is shown in the first of the operational diagrams.

Depression of the brake pedal displaces fluid from the master cylinder, through the hydraulic section of the Airpak unit and into the pipeline to the wheel cylinders. Because of the resistance at the brakes, the fluid pressure in the circuit increases and so causes the control valve piston and diaphragm to move to the right, thereby closing the atmospheric valve and isolating the control tube from atmosphere. Increasing hydraulic pressure causes the diaphragm centre-piece to move the poppet assembly to the right, so lifting the first stage of the compressed air valve off its seat. Compressed air therefore passes through the valve, into the chamber to the right of the diaphragm, and thence through the control tube to the power cylinder. The



On the left is the 3 in or 4 in Airpak, and below is shown the 4½ in unit, which has a longer air reservoir



A *brake pedal*; **B** *fluid reservoir*; **C** *hydraulic master cylinder*; **D** *Airpak unit*; **E** *air pressure gauge*; **F** *pipeline to front and rear brakes*; **G** *S.C.4 compressor*; **H** *feed pipe to Airpak reservoir*; **J** *feed from reservoir to governor*

Diagrammatic representation of a typical air assisted braking system incorporating an Airpak servo unit supplied by an S.C.4 compressor

power piston is, consequently, subjected to a pressure differential, which moves it and the hydraulic piston to the right.

This stage is termed the *power crack-off point* and normally occurs when the hydraulic input pressure reaches 40 lb/in^2. On the initial movement of the hydraulic piston, the stem of the yoke is ejected, under the influence of the check-valve spring, from the piston; this allows the ball to seat, so that the fluid is trapped ahead of the hydraulic piston. Obviously, in these circumstances, the total thrust exerted by the piston on the fluid column to the brakes is the sum of the thrusts applied to it by the push rod and the fluid pressure from the master cylinder. The second diagram illustrates this condition.

When a pressure differential is applied across the power piston, there is a similar differential across the diaphragm, which results in a reaction force moving the diaphragm so as to close the air inlet valve and re-open the atmospheric valve. This force is balanced by the hydraulic input pressure applied to the control valve piston and is, therefore, transmitted back through the system to the brake pedal, to enable the driver to sense the degree of application; at the same time, as the hydraulic piston advances along its cylinder, fluid from the master cylinder enters the chamber behind it, and the consequent movement of the pedal also assists the driver of the vehicle in sensing the degree of brake application.

When the required degree of braking is obtained, the hydraulic pressure behind the control valve piston becomes constant and a state of equilibrium is reached. In this state, the poppet assembly adopts what is termed the *lap* position, as is shown in the third diagram, in which both the air and atmospheric valves are seated, and the effort applied to the brake shoes is sustained at a constant value.

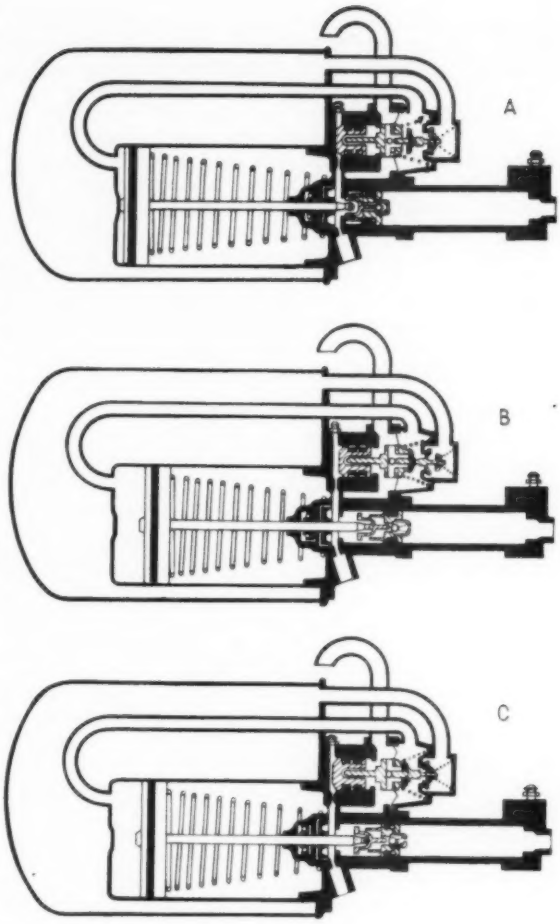
Increased load on the brake pedal produces a corresponding increase in the fluid pressure on the control valve piston. Consequently, the piston and diaphragm assembly move to the right to reopen the air valve, and so to increase the pressure applied to the power piston. At the full travel position of the control valve assembly, the air valve is held off its seat, so the maximum air pressure available in the reservoir is applied to the power piston. Once this stage is reached, the only additional braking effort available is that applied directly by the fluid pressure from the master cylinder to the hydraulic piston. However, the degree of servo assistance available is such that, assuming the unit to be correctly matched to the vehicle and full air pressure to be available, this situation is unlikely to occur except in an emergency.

A reduction in the effort at the brake pedal decreases the

fluid pressure on the control valve. As a result, the control valve piston and diaphragm move to the left, so the atmospheric valve re-opens. Some of the air is therefore exhausted from the power cylinder, and a balance is obtained at a lower pressure.

When the brake pedal is completely released, the control valve piston and the hydraulic piston are no longer subjected to input pressure. The air pressure on the right-hand side of the diaphragm, aided by the diaphragm spring, then moves the control valve assembly to the left, re-opening the atmospheric valve and releasing the compressed air from the power cylinder. Under the influence of the piston return spring and the residual pressure in the hydraulic cylinder, the power and hydraulic pistons are also moved to the left. As the hydraulic piston approaches its released position, the base of the yoke contacts its stop washer in the end cover; the final movement of the hydraulic piston causes the stem of the yoke to push the check-valve ball off its seat once more, so enabling any surplus fluid beyond the hydraulic piston to flow back to the hydraulic reservoir.

It will be apparent that the design of the Airpak unit is such that, in the event of failure of the compressed air supply, positive though unassisted braking can be obtained. The check-valve then remains open, since the hydraulic piston is held in the fully released position by the action of the power piston return spring. As a result, the fluid passes through the hydraulic cylinder directly to the wheel cylinders.



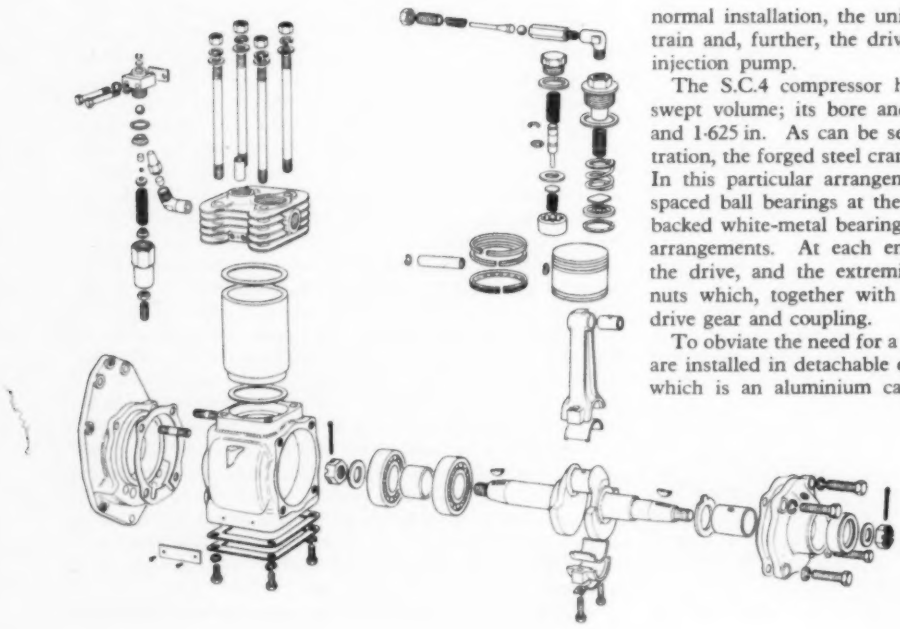
Right: These three diagrams illustrate the operating stages of the Airpak servo. Diagram A shows the brakes released position, whereas in B, brake pedal movement has resulted in the application of air pressure through the open air valve to the servo piston. In diagram C, the unit is in the lap condition, in which both valves are closed

S.C.4 air compressor

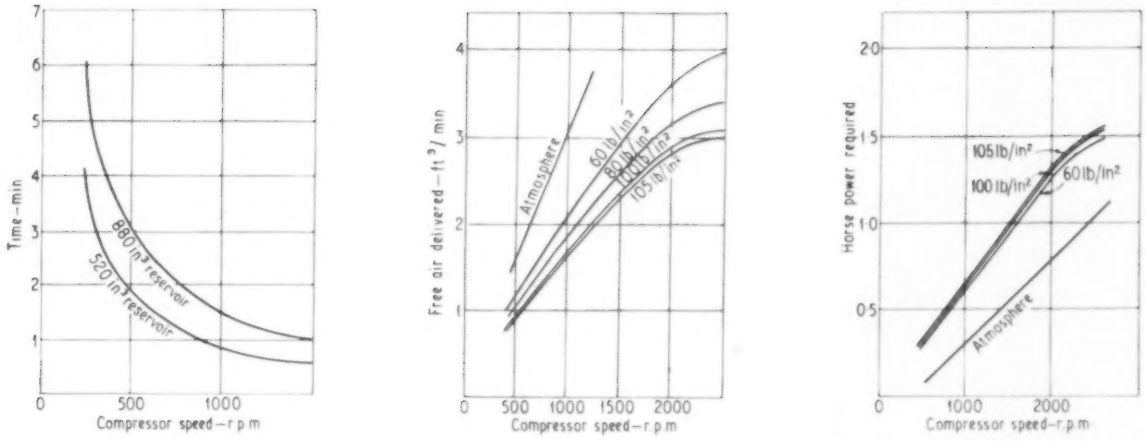
This compressor is of sturdy design and, though orthodox in most respects, incorporates the unloader and governor mechanisms. There is only one basic model, but it is available for spigot, base, flange or bracket mounting. In a normal installation, the unit is driven from the timing gear train and, further, the drive is taken through it to the fuel injection pump.

The S.C.4 compressor has a single cylinder, of 5·75 in^3 swept volume; its bore and stroke are respectively 2·125 in and 1·625 in. As can be seen from the accompanying illustration, the forged steel crankshaft embodies balance weights. In this particular arrangement, it is carried in two widely spaced ball bearings at the drive input end, and in a steel-backed white-metal bearing at the rear—there are also other arrangements. At each end of the shaft, a key transmits the drive, and the extremities are threaded to receive the nuts which, together with washers, are used to retain the drive gear and coupling.

To obviate the need for a split crankcase, the main bearings are installed in detachable end-covers spigoted into the case, which is an aluminium casting. At the outer end of the



The construction of the S.C.4 compressor is straightforward and robust. Features include and unfinned cylinder barrel of cast iron, an aluminium head, and a connecting rod that is a light alloy dicasting. The crankshaft is counterweighted



Performance curves of the S.C.4 compressor. Left: The time taken to charge the reservoir at various speeds. Middle: Delivery of free air plotted against compressor speed, for various back pressures. Right: Power required to drive the compressor, again against different back pressures

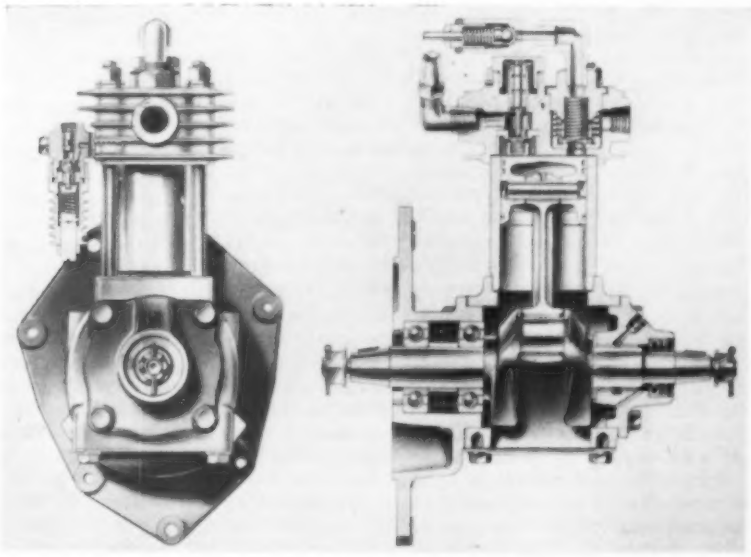
rear cover is a counterbore to house a lip type oil seal. To control end float of the shaft, a white-metal faced steel thrust washer is interposed between a shoulder on the crankshaft and the rear end-cover.

The connecting rod is a light alloy pressure diecasting; its big-end is of the conventional split type and houses a steel-backed white-metal shell type bearing. In the small-end is a steel-backed, lead-bronze bush. The gudgeon pin is fully floating and is located by circlips in the bosses of the piston, which is a diecasting of low-expansion aluminium and carries one scraper and two compression rings. Of these three rings, the scraper is installed below the gudgeon pin, near the bottom of the skirt.

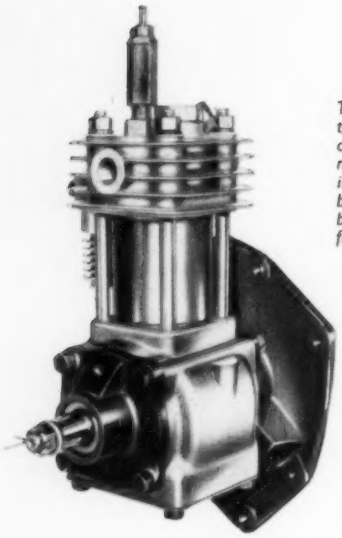
For lubrication of the unit, oil at a pressure of 40 to 60 lb/in^2 is taken from the engine system. It is fed to the end cover containing the plain bearing, into which it passes through a radial drilling and a circumferential groove in the bearing surface. Thence, oil is conveyed to the big-end through the usual passage drilled obliquely in the crankshaft. The ball main bearings, small-end bearing and cylinder walls are lubricated by splash. A hole drilled in the housing prevents the build up of pressure between the oil seal and the plain bearing; the surplus oil passes to the crankcase of the compressor, whence all the lubricant draining from the unit passes back to the engine sump.

The plain cylinder barrel is of centrifugally cast iron, and its wall is of generous thickness, for rigidity; at the lower end is a male spigot, which enters a corresponding counterbore in the upper face of the crankcase, and the top end of the barrel spigots into the head. On the cylinder head, which is an aluminium casting, there are five horizontal fins. The head and barrel are held down by four studs, which pass through holes in the head only and are screwed into the crankcase.

Embodied in the head are the inlet and delivery valve assemblies. The inlet valve consists of a hardened and lapped steel disc, which is lightly spring loaded from beneath against a replaceable valve seat in the inlet passage of the head casting. A square-shape steel plate, also hardened and lapped, comprises the delivery valve. It is held down on to its replaceable seat in the outlet tract by a coil spring housed in a screw-in cap. The valve seating is held down by



In the left-hand view, the governor unit can be seen alongside the cylinder; it is secured to the head casting by two bolts. The inlet and delivery valves, as well as the unloader mechanism and safety valve, are visible in the right-hand illustration. Separate castings, spigoted into the ends of the crankcase, form housings for the crankshaft main bearings and the oil seals



This three-quarter view of the compressor shows the crankshaft extension, used normally to drive the fuel injection pump. A base or bracket type mounting can be employed instead of the flange type illustrated here

another spring, which is positioned between it and the cap.

Mounted by the inlet valve is an unloader mechanism controlled by a governor valve fitted on the side of the head. The governor connection communicates with the air reservoir and when a pressure of 105 lb/in^2 is attained in this reservoir it moves the spring-loaded ball of the governor valve from its upper seat on to the lower one: this allows air to pass through drilled holes in the cylinder head to the unloader chamber; the unloader valve is depressed and lifts the inlet valve off its seat so that the air in the reservoir is not further compressed.

As soon as, owing to brake operation, the reservoir pressure falls to 91 lb/in^2, the governor ball-valve, under the action of its spring, moves on to the upper seat. In so doing, it allows the pressure in the unloader chamber to be released through a small hole in the side of the governor housing to atmosphere, so permitting the inlet valve to return to its seat. There is a secondary precaution against damage to the equipment should the governor or unloader mechanism fail: this is a safety valve, also of the spring-loaded ball type, which is screwed into the top of the cap over the delivery valve.

The weight of a complete S.C.4 compressor varies with the type of mounting, but is normally in the region of 20 lb. On a basis of the piston displacement, the rated capacity is 3·3 ft^3/min at 1,000 r.p.m.—the normal operational speed—and 4·0 ft^3/min at 1,250 r.p.m. The rates of delivery of free air against various reservoir pressures are shown on one of the accompanying graphs. Other graphs indicate the power required to drive the compressor, and the time taken at various speeds to charge the smallest and largest of the three reservoirs. The maximum operating speed of the compressor is 2,800 r.p.m, but adequate air flow over the head and barrel must be ensured if a speed above 1,500 r.p.m. is likely to be sustained for long periods.

High Density Polythenes

IN THE United States of America, the quantity of high density polythenes used in motor vehicle construction is increasing at a considerable rate. According to a study just completed by Phillips Chemical Co, as much as 6,000,000 lb of these resins may be used in a wide range of applications by the four major U.S. car manufacturers next year. This volume represents an estimated 4,500,000 lb increase over that used in the 1960 cars. The estimate is based on actual new car sales for the first nine months of 1960 and the weight of projected resin applications already in use or specified for use in 1961 by the leading American car manufacturers.

Applications range from interior trim components to heater ducts and miscellaneous functioning items. During 1960, the principal automobile application was the seat side shields in the Ford model, as described in the July 1960 issue of *Automobile Engineer*. Other components, more recently made from this plastics material, are various duct adaptors and cowl panels for fitting beneath the dash. Its use is also being extended to glove box lids and covers for electrical components. Studies are being made with a view to applying the material to upholstery, floor mats and headlinings, and certain other uses are being considered.

Industrial Hand Tool

AFTER a long careful study of requirements for industry, a new hand tool has been developed by Firth Cleveland Tools Ltd. It is similar to the well known Surform tool, which is like a flat rasp or file. Several changes have been made in the design, to render it suitable for industrial use: the body is a steel pressing, instead of a casting, so that it is unlikely to be broken if roughly treated; another modification is the setting of the teeth so that they do not project so far beyond the peaks of the corrugations as they do in the tools designed for cutting softer materials; as a result of this latter feature, premature tooth breakage should not occur. In fact, the blade was designed for cutting, smoothing, shaping and trimming metallic materials, such as mild steel, aluminium, copper and brass, as well as softer ones.

Alternative handles are available: Industrial Tool Number 150 has a straight wooden handle, while Number 151 has a cranked handle; both are adjustable and have locating studs for positioning them, and each is supplied with a removable forward guide. Replacement parts, including the blades, are stated by the manufacturers to be readily available.

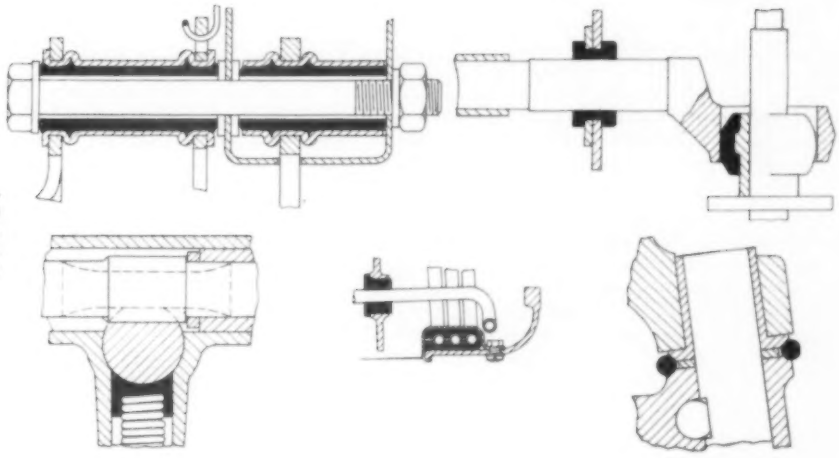
Propathene

IT HAS recently been announced by Imperial Chemical Industries Ltd. that they have completed a manufacturing unit capable of producing 11,000 tons a year of polypropalene, a plastics that hitherto has not been made in bulk in Great Britain. The name given to the I.C.I. product is Propathene. Plans are already under way for rapidly doubling the capacity of this plant and, at a later stage, trebling or even quadrupling it.

There are two reasons why I.C.I. are confident that the new material is of major significance. One is that its raw material is cheap and abundantly available from oil cracking and refining plants. Secondly, its properties, including low density, high strength and temperature resistance, make it useful for a wide range of applications. Propathene is a plastics material that is easy to handle with conventional machinery, by injection moulding, extrusion and other commonly used processes. It is expected that later there will be a large demand for the material in film and fibre form. The film is of considerable potential interest because of its clarity, outstanding gloss, stability and barrier properties.

VULKOLLAN PLASTICS

A Material That is Suitable for Bearings, Seals and Many Other Automobile Applications



The new plastics material is widely employed on both quantity produced and other cars. In the illustration on the right are shown several representative applications in the B.M.W. 700

AMONG the new plastics materials that are being widely used in motor vehicles is Vulkollan, which is available in a number of different grades. The properties of this material are described in a booklet entitled "Vulkollan as an Elastic Construction Material", which can be obtained from Rubber Plastics Ltd, 1 Great Cumberland Place, London, W.1. Since the booklet was produced, an additional grade Vulkollan A, has been developed. This grade can be extruded and pressed in much the same manner as rubber.

By virtue of its elastic and vibration damping properties, Vulkollan is suitable for bearings in suspension systems and other applications where relatively high strength, elasticity and vibration damping are essential. Examples of applications are door locks and drawbar and tie-rod heads. The material is also used as an elastic layer for machine foundations and as limit stops for sprung systems. When the dynamic loading is high, it is necessary to ensure that the damping is not likely to cause the temperature of the material to rise to a value higher than that specified by the suppliers, which, in general, is 80 deg C, although temperatures as high as 130 deg C can be withstood for a few hours.

When Vulkollan is used as a bearing material, dry lubricating additives such as graphite and molybdenum disulphide can be incorporated in it to give satisfactory operation for a reasonable period should the normal supply of lubricant fail. The material is practically unaffected by water, and so the close tolerances required for friction bearings can be realized. Since the material is not only elastic but also virtually incompressible, it is important that it be installed in such a manner that axial deformation can occur, especially if the temperature of the material is likely to vary to any appreciable extent. In general, bearings of this material are suitable for oscillating components or for revolving shafts where the specific pressures may be high but the speeds of rotation low.

Because of its high strength, damping characteristics, and low Young's modulus, the material is particularly suitable for vibration couplings. With this material, it is possible to design relatively small couplings, which, therefore, tend to be less subject to centrifugal loading than those made from some of the other materials.

For the production of toothed wheels, the casting process is employed, and this obviates expensive machining operations. Wheels produced from Vulkollan are suitable for low torques at low pitch-circle speeds. For example, if the compression set is 3, and the pitch-circle speed 9 m/sec, a flexural stress of 80 kg/cm^2 is permissible with lubricated toothed wheels and 35 kg/cm^2 at the root with unlubricated wheels. A new development is the employment of a Vulkollan ring, cast between a hardened steel toothed rim and a steel core.

Because of its relatively low Young's modulus, high elasticity and good compression resistance, the material is particularly useful for seals. Components of this type have been used successfully in hydraulic equipment, pipelines and valves. It has also been employed as a lining for rotary pumps delivering liquids in which abrasives are suspended.

Engine Wear Discussion

AT A meeting held recently at Shell's Thornton Research Centre, in Cheshire, about 200 experts from 11 countries discussed wear in road vehicle engines. Among the papers that were presented was a report on the recent work at Thornton on piston ring wear. This work has shown that, so far as vehicles are concerned, the latest improvements in engine design have practically eliminated the type of ring wear associated with acid corrosion. Further studies now in progress on wear, other than that caused by corrosion, of piston rings are expected to lead to developments that will give even longer engine life than is obtained at present.

Prof. Ir. H. Blok, of the University of Technology in Delft, Holland, discussed work that he has done on the measurement of the extremely high temperatures developed at the microscopic peaks of metal surfaces when rubbed together. These temperatures, known as flash temperatures, can be high enough to cause the metal to melt at the points of contact. At Thornton, Prof. Blok's flash temperature concept has been applied with a view to obtaining a better understanding of the troublesome problems of valve gear wear in engines of recent design. A paper on these studies, containing fundamental information that is expected to contribute greatly to cam and gear design, was a highlight of the conference and attracted considerable interest.

FUEL ADDITIVES

Part I: Developments in Chemical Remedies for the Common Combustion Disorders

By E. M. GOODGER,* M.Sc. (Eng.), Ph.D., A.M.I.Mech.E., A.F.R.Ae.S., F.Inst.Pet.

In the sales promotion of fuels for the modern motor car, great emphasis is placed upon additives and the outstanding benefits that result from their use. It is of interest, therefore, to examine these materials in detail: what are they, what is their function, and how do they perform it? Although commercial security is an important consideration, the oil companies are able to give a general indication of the form that their additives take and, dispersed in the technical literature available, is evidence of the performance obtained. In this article an attempt is made to collate some of the more pertinent results obtained with these additives and to compare the mechanisms by which they function.

BASICALLY, as is well known, fuels are built up of selected hydrocarbon components termed blending agents, usually in appreciable proportions, that is, up to 40 per cent by volume. Additives, on the other hand, are much more potent, and are incorporated in traces only, that is, up to about 0·1 per cent by volume. Their duty is to alleviate the combustion problems that arise when operating conditions become severe or unfavourable. It is convenient, therefore, to group additive types under the headings of the combustion problems with which they are associated.

For an additive to be wholly acceptable, it must have certain basic requirements, as follows:

1. It must be effective in the desired reaction
2. Soluble in fuel under all practical conditions
3. Stable in storage and have no adverse effects on fuel stability
4. In the liquid phase at normal handling temperature, and volatile to give rapid vaporization in the manifold
5. It must not lead to the production of deposits harmful because of either their nature or the quantity produced
6. Nor must it have deleterious subsidiary effects upon performance
7. It must not damage engine components
8. Its water solubility must be negligible, to minimize handling losses

In addition, it is advantageous for an additive to be non-toxic. That any substance will be found which will meet all the above requirements is highly improbable. However, as in most engineering practice, suitable compromises can be made to permit application.

The combustion problems discussed in the following sections can be tackled also by alternative means, such as improvement of combustion chamber design, constructional materials, and fuel and oil quality, together with, in the case of the compression-ignition engine, internal heating elements and fuel systems of the pilot-injection type. Employment of additives, therefore, is only one of a number of measures than can be taken for the solution of combustion problems.

The knock problem

Knock has bedevilled the spark-ignition engine from the earliest days, and much painstaking research has been necessary for the attainment of the present level of understanding of its mechanism and for its control. In knock-free conditions, the progress of the spark-ignited flame throughout the combustion chamber produces a smooth rise in pressure up to the end of combustion. If, however, the rising pressure over-stresses the unconsumed portion of the charge, this end gas reaches a condition under which it ignites spontaneously. The resulting explosion leads to violent vibrations of the gases in the chamber, and of the chamber walls. This, of course, is knock, as indicated by the familiar pinking noise when an engine is highly loaded, for example, in a low-speed hill climb in top gear. Most car engines are robust enough to withstand considerable knock but, in extreme cases of continuous heavy knock, the pressure surges incurred can eventually punch holes through piston crowns or cause other damage.

The effectiveness of anti-knock additives is measured by the increase they effect in anti-knock quality of the treated fuel, that is, the increase in octane number. In general, results from the Research method of octane number determination give in the laboratory the most realistic indication of what the performance on the road will be.

Incomplete combustion of fuel and oil leads to deposits of ash on the walls of the combustion chamber. These deposits are augmented by dirt in the air, and by unscavenged additive products. The proportion of the combustion heat that normally flows through the chamber walls may be largely absorbed by these deposits, and transferred back to the fresh charge. Also, by reducing the clearance volume, the deposits increase the compression ratio. With a given fuel, the tendency to knock will increase with time as the deposits build up and become increasingly effective. In other words, the octane requirement of the engine rises, the octane requirement being the minimum anti-knock quality of a fuel to give knock-free operation in the engine. Results from some elaborate experiments show the thermal effects to be dominant, Fig. 1, and that it is possible to relate semi-quantitatively the specific heat of the deposits to their effect in increasing knock.

Tetra-ethyl lead

The first dramatic advance made in the search for anti-knock additives was during the years 1916 to 1921 when Kettering and Midgley, in America, working their way through prospective agents such as iodine, aniline, and selenium, discovered the effectiveness of lead compounds. Lead is, of course, a heavy element, and can exist in a number of different oxide forms. It is postulated that small particles of lead oxide become activated during the com-

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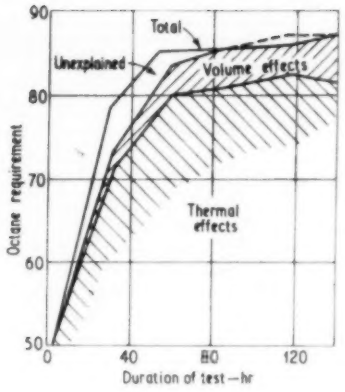


Fig. 1. Contribution of thermal and volume effects of deposits to total increase in engine octane requirements with time[1]

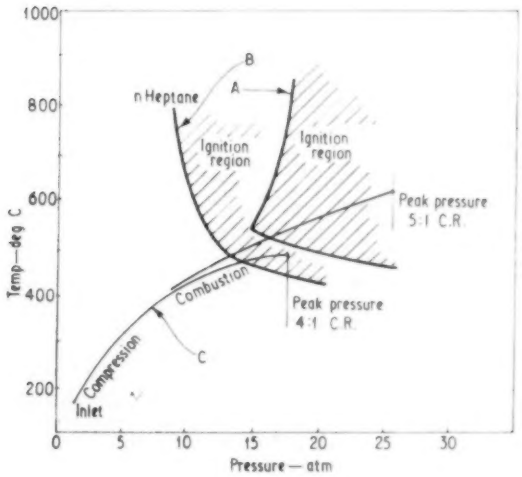


Fig. 2. Temperatures and pressures experienced in the end gas of an engine that is firing, compared with those required for spontaneous ignition under severe motoring conditions[2]

bustion process, and are then able to absorb the energy released within the end gas during chain-branching reactions of fuel and oxygen prior to ignition. These interruptions delay the process of spontaneous ignition, and permit the spark-ignited flame to consume the end gas in the normal way. The potency of the lead molecule is due to its ability to repeat this restraining action many times during each combustion process.

In order to be applied successfully as a fuel additive, the lead has to be made fuel-soluble, or miscible, as indicated earlier. This was achieved in 1921 by combining the elemental lead with organic radicals which are themselves fuel-soluble, to give tetra-ethyl lead, or TEL. The chemical formula of this material is $Pb(C_2H_5)_4$.

In Fig 2, suppression of knock by TEL is illustrated for n-heptane, the lower reference anti-knock fuel. These curves were prepared as follows: by motoring a CFR engine under severe conditions, of high inlet temperature and compression ratio, stoichiometric mixtures of leaded and unleaded n-heptane with air were made to ignite spontaneously at the compression peak; this permitted the construction of the motored ignition curves, which show the minimum severity required to produce spontaneous ignition within the time available per stroke, at the test speed of 1,800 r.p.m. Other tests, together with calculation, provided the temperature and pressure records of the end gas when the engine is operated under normal fired conditions. The relative positions of the two families of curves show how the added lead provides a higher anti-knock quality by raising the operating severity necessary to promote spontaneous ignition.

In the early years, many serious problems had to be solved before TEL could be released for general service. Toxicity and fouling had to be controlled, since lead is a known cumulative poison, and deposited lead salts can play havoc by corroding engine components such as sparking plugs and exhaust valves. Bromine, in the form of ethylene dibromide, EDB, with the formula $C_2H_4Br_2$, is added in order to combine with the lead after it has fulfilled its purpose, and to allow it to be scavenged more completely, in the form of volatile lead-bromine compounds, from the combustion chambers. For automotive use, ethylene dichloride, EDC, which is $C_2H_4Cl_2$, is also added in conjunction with EDB.

This mixture of TEL with its scavengers is known as

Table—CONSTITUENTS OF ETHYL FLUIDS[3], PER CENT MASS

Constituent	*Motor mix*	*Aviation mix*
Tetra-ethyl lead	61·48	61·41
Ethylene dibromide	17·86	35·68
Ethylene dichloride	18·81	Nil
Dye	0·12	0·05
Kerosine and impurities	1·73	2·86

Ethyl fluid, and that containing the quantity of scavenger required theoretically to combine completely with the lead is designated the One Theory or 1T mix. Ethyl motor mix contains 0·5T EDB and 1T EDC, whereas Ethyl aviation mix contains 1T EDB. The percentage mass proportions of these components are shown in the Table. For convenience, the concentration of Ethyl fluid in a leaded fuel is expressed in terms of the active anti-knock component, that is, the TEL. The maximum TEL concentration of 3·6 ml/Imp gal in motor gasolines, therefore, represents an Ethyl fluid concentration of about 6 ml/Imp gal respectively.

Fuels respond in different degrees to the introduction of additives, and this response depends upon the nature and proportion of the fuel components; all fuels, however, show a tendency to saturation with lead. A typical response to the first millilitre of TEL is five octane numbers, Fig. 5, but consecutive increments fall rapidly as subsequent additions are made.

Operational difficulties associated with the use of leaded fuels are incomplete scavenging and lack of uniformity of distribution. With regard to the former, the organo-halide scavengers previously discussed are considered to be about 95 per cent effective, so that some 5 per cent of the lead remains in the chamber, where it may combine with carbon deposits and give rise to surface ignition. This aspect will be dealt with in Part II of this article, to be published later.

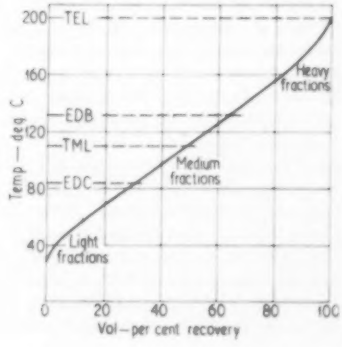


Fig. 3. Distillation curve for typical motor gasoline, and boiling points of additives

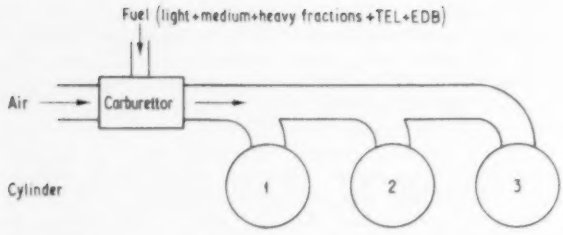
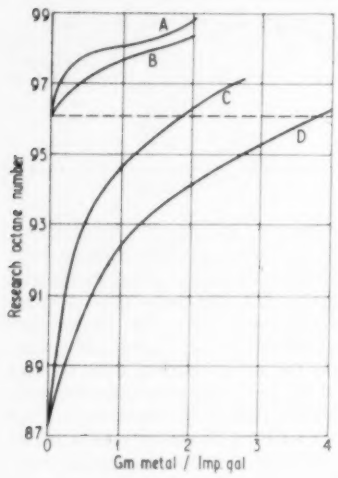


Fig. 4. Maldistribution with a three cylinder, straight-rake manifold



A *Mn response—3·8 gm Pb/Imp gal;* **B** *Pb response —1·9 gm Mn/Imp gal;* **C** *Mn response—zero Pb;* **D** *Pb response—zero Mn*

Fig. 5. The diagram on the left indicates the response of a motor gasoline to manganese and lead.[5] Manganese was added in the form of MD-CMT and lead in the form of TEL

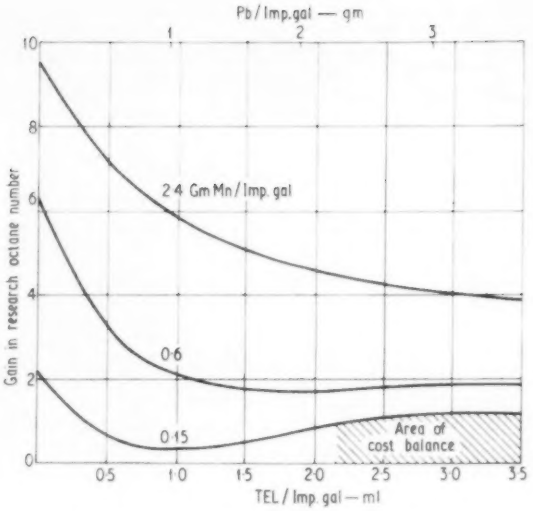


Fig. 6. This diagram is a replot of Fig. 5, to show the promoter effect that manganese has at high concentration of TEL in the fuel

With regard to the second of the difficulties mentioned in the preceding paragraph, this concerns the maldistribution of fuel fractions and fuel-air proportions through the inlet manifold system to the individual cylinders of multi-cylinder engines. Owing to incomplete vaporization, the heavy fractions pass through the system in the liquid phase, taking with them the TEL, which boils at 200 deg C, but not the lead scavengers, which boil at lower temperatures, Fig. 3. While the inertia of the liquid droplets can cause maldistribution throughout the manifold, the gases are generally distributed fairly uniformly: so, in the worst case, the mixture distribution pattern could appear as in Fig. 4. From this illustration, it can be seen that each cylinder is operating under adverse conditions, and problems of knock, bromine corrosion, and lead fouling ensue. Whereas attention to the geometry of the inlet manifold can improve the distribution of fuel quantities, the effects of fuel quality maldistribution could be minimized either by raising the boiling point of the lead scavenger, or by lowering the boiling point of the lead carrier. Regarding the former method, a test programme was conducted some years ago by Shell, with acetylene tetrabromide, ATB, which is $C_2H_2Br_4$, and has a boiling point of 244 deg C. Although the engine test results were encouraging, instability in storage rendered the use of the compound impracticable. Recent work representing the latter method is discussed under the heading Tetra-methyl lead. In supercharged aero engines, a palliative measure adopted has been the maintenance of the gases in the manifold at a minimum temperature of, for example, 40 deg C, in order to limit the proportion of the unvaporized fuel.

Tetra-methyl lead

In an attempt to counter the maldistribution problem, a lighter organo-lead compound has been formulated by combining lead with methyl, instead of ethyl, radicals to produce tetra-methyl lead, TML; the chemical formula for this compound is $Pb(Ch_3)_4$. TML also is poisonous; moreover it is explosive but can be stabilized. When first tested years ago, TML did not prove worthy of commercial exploitation, but recent work has revealed a valuable application to current motor fuels of the catalytic reformate type. In these fuels, the anti-knock quality of the medium fractions can be as much as 20 octane numbers below those of both the lighter and heavier fractions. Since TML boils at 110 deg C, which is within the medium fraction range, knock protection is provided where it is needed, and improvements have been noted up to 6 road octane numbers higher than those obtained with TEL. This beneficial effect is noticeable particularly in cars with manually controlled transmissions in which, hitherto, catalytic reformate fuels had been found to give much lower road octane numbers than predicted from either Research or Motor method ratings. Furthermore, TML has been found to be a more effective anti-knock agent in the Research and Motor method laboratory tests with catalytic reformate fuels. This advantage is particularly marked at the higher initial levels of anti-knock quality.[1]

Promising manganese compounds

Because of the economic factors involved in the continuing rise in compression ratios and in octane requirements, recent work has been directed towards the preparation of new commercial anti-knock compounds. Development work has been reported by the Ethyl Corporation[2] on the methyl derivative of cyclopentadienyl manganese tricarbonyl, referred to as MD-CMT or, commercially, as AK-33X. This material exists in the liquid phase at normal conditions, and boils at 233 deg C.

In Fig. 5, the responses of a gasoline to manganese and to lead are shown comparatively. On a basis of equal increment in Research octane number, the mass of additive metal required with manganese is only half of that with lead. The greater effectiveness of manganese is seen again in the upper curves in the illustration, where the fuel already

contains some additive to bring the initial Research octane number to 96·1. Replotting the curves on a basis of octane gain reveals an interesting and valuable promoter effect of manganese upon TEL, Fig. 6. These latter curves show a general fall in the manganese response with increased TEL concentration, but those of them for very low manganese concentrations rise at TEL concentrations in excess of about 1 ml/Imp gal, giving an anti-knock bonus. The trace of manganese apparently promotes the activity of the lead, and this is most apparent within the region of low manganese and high TEL concentrations, where economic balance will normally occur.

Since, on a metal mass basis, MD-CMT is approximately four times the price of TEL, its use at first will probably be to provide this boost to the effectiveness of TEL. The mechanism of the boost effect is still under investigation, but there are indications of a chain-breaking process, similar to that with TEL, and this may be due to either the manganese affecting the lead-oxide particles to give either an increased catalytic surface action, or an increased specific surface owing to reduction of the particle sizes.

The introduction of any new material in a fuel raises the question of engine durability. Exhaust valve life has been found to be shortened when low concentrations of MD-CMT are used, but restored to normal with higher concentrations. Sparking plug life may be either increased or decreased, according to the degree of service severity. The use of phosphorus as a corrective agent, to the extent of about 0·4T for the TEL present, extends valve life, and eases the plug problem of low-resistance deposits that build up during light duty operation: this will be dealt with in more detail in Part II of this article. However, plug problems in the form of electrode bridging under heavy duty conditions, are not solved by the employment of phosphorus. Engine wear and corrosion are not aggravated by MD-CMT.

Organic compounds

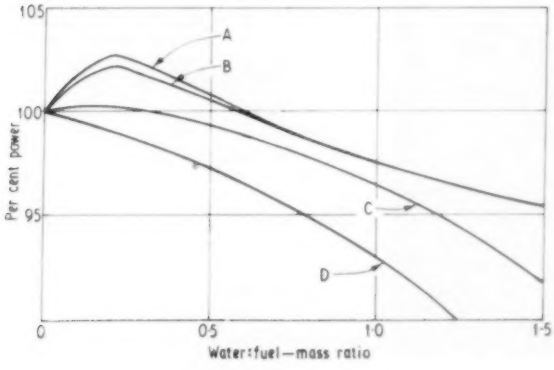
Lovell[3] reports that the organic compound, tertiary butyl acetate, is particularly effective as an anti-knock additive in high-performance fuels of over 100 octane number. This compound is used in concentrations up to 1 per cent, and apparently increases, as does manganese, the effectiveness of TEL.

Water injection

Improvements that have been claimed to accrue from water injection include suppression of knock, and the reduction of fuel consumption and carbon deposits. Owing to the variety of different effects of water in the engine, and the relative magnitudes of these effects, water injection must be applied with care if the results are to be truly beneficial. A series of experiments with water injected at different instants during the induction and combustion processes illustrates this point[4]: four different methods were investigated, and they included injecting water continuously near the entrance to the inlet manifold, and on a timed basis into both the inlet port and the combustion chamber during the compression and power strokes.

Fig. 7. The effect of water injection on power output of the engine

A *port injection;* **B** *manifold injection;* **C** *chamber injection—compression stroke;* **D** *chamber injection—power stroke*



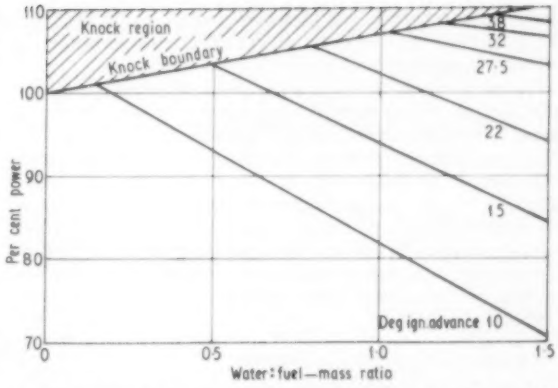
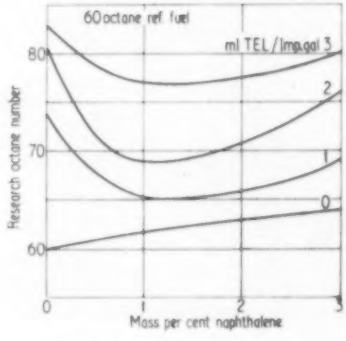


Fig. 8. The effect that water injection into the induction manifold has on the knock-limited power output of a spark ignition engine[4]

Fig. 9. On the right is a diagram showing the influence of naphthalene on octane rating



The results, shown in Fig. 7, indicate that under normal operating conditions water, owing to its presence in the burning gases, tends to reduce output: other tests have shown this to be due to a lower flame speed. The results also show, however, that a very slight initial gain in power arises by virtue of the presence of water during compression; this follows from the cooling effect of water vaporization, and the reduced compression work. Injection of water into the intake charge gives a 2 or 3 per cent increase in power, owing to the increased charge density on cooling. However, once the incoming charge is water-saturated, no further vaporization of water can occur, and the power falls with further injection, as with the other arrangement. The slight superiority of timed port injection over continuous manifold injection was probably due to the ejector effect through the inlet port. Nevertheless, this is not sufficient to justify the complication of a timed injection system, and in practice the continuous injection principle is invariably adopted.

These tests also showed that, owing to the cooling effect in the end gas, water increases the knock-limited power. From Fig. 8, it can be seen that water injection should be applied only when operating conditions approach the knock region, and for the purpose of maintaining freedom from knock. Alternatively, when water injection is applied, the

potential improvement in performance can be realized only by increasing the severity of operation, for example, by advancing ignition timing.

There is no doubt that water does suppress knock, but whether, in motor vehicles, this results in more power or greater economy depends largely upon the method of driving. The greater degree of engine cleanliness obtained with water injection is probably due to the combustion of carbon deposits by the oxygen released from decomposed water molecules. Water cannot be added to the fuel in its bulk storage tanks, because of its adverse effects upon normal combustion, and also on account of practical difficulties with regard to separation, tank corrosion, fuel-line icing, and carburettor blockage.

Anti-knock effects of naphthalene

Naphthalene compounds have long been reputed to promote gains in economy, but no results were available on the anti-knock effects of naphthalene until 1953. These results, presented in Fig. 9, in general indicate adverse effects, except in the case of lead-free fuel. Furthermore, the high naphthalene concentration necessary to produce any worthwhile effect in the lead-free fuel gives rise to serious blockage difficulties in respect of the deposition of solid naphthalene in fuel lines and the carburettor, and hence starvation of naphthalene from the combustion chambers.

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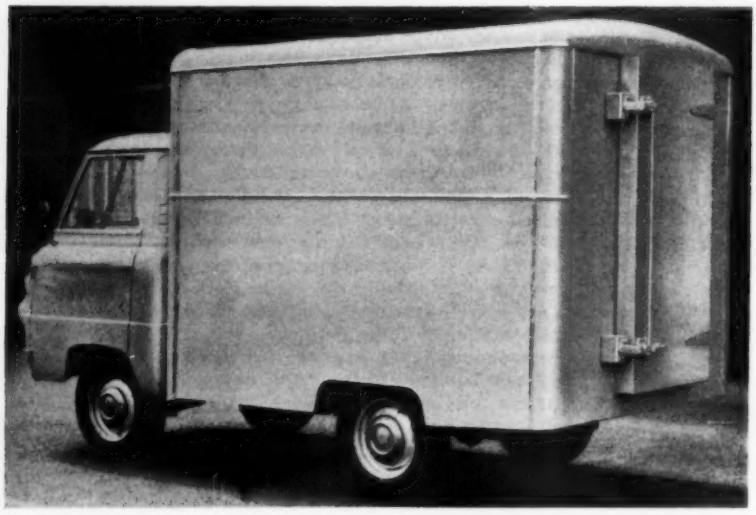
Structural Use of Plastics in an Insulated Delivery Van Body

WITH the rapidly growing demand for frozen foods has come the need for quick distribution and delivery. Conventional methods of insulated body construction have tended to impose a serious weight penalty on chassis of 1 ton and under, so, with weight saving in mind, Mann Egerton Ltd, of Norwich, have produced a design which embodies unusually extensive use of glass fibre reinforced Bakelite polyester resin, notably in the body frame members. The new delivery van is based on a Ford 15 cwt forward control chassis, and the use of reinforced plastics in the body has resulted in a weight saving of 4 cwt relative to the orthodox steel and aluminium construction, thereby making it possible to increase the payload to 13 cwt. Other noteworthy features of the design include compactness and ease of cleaning and maintenance, both inside and out.

The framework of the body is built almost entirely from 4 in × 1 in channels of U-section, and in the sides of the vehicle these are joined together by angle pieces, also of reinforced resin. Again, U-channels are used in the floor structure, but with steel reinforced plates at every joint. Foam blocks of polystyrene, 3 ft × 2 ft × 4 in, form the insulating medium, and they are slid into and located by the U-channels. Resin bonded plywood, $\frac{1}{8}$ in thick, is used for the floor, which is finally overlaid with reinforced resin to form a continuous surface. Abrasive grit, mixed with the resin for this last operation, provides the floor with a durable, non-skid surface.

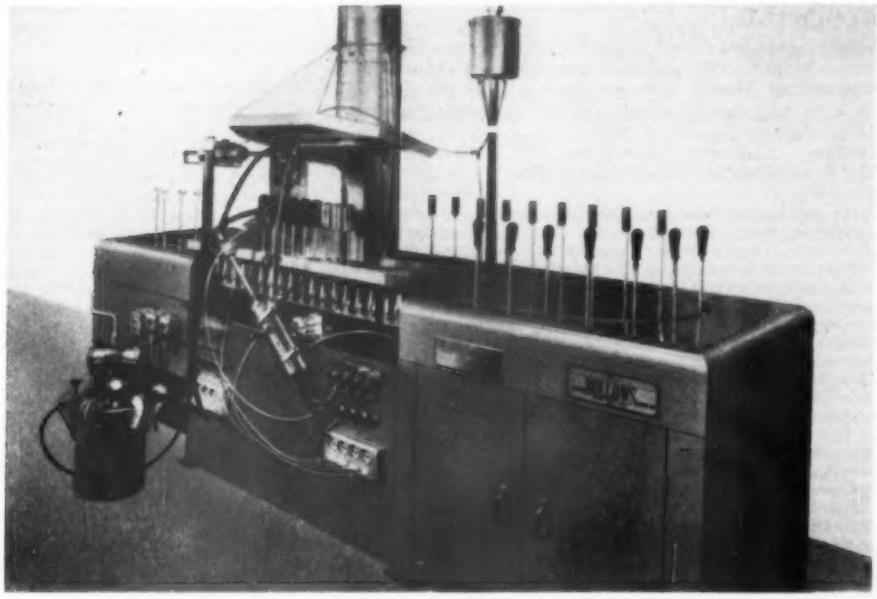
All the panelling is in self-coloured, prefabricated, reinforced resin sheets which are secured to the channel sections by polyester resin. The roof panels overlap the side panels at the cant rail. After assembly, corner pieces of reinforced resin are fixed to the bodywork, and all external joints are covered by extruded aluminium section. The door is of the double-action type for super freeze containers.



The body frame, panelling and insulation of this 15 cwt van are all made of plastics material with the result that the ratio of laden : unladen weight is unusually high

BULLOWS PAINT SPRAYING MACHINE

Automatic Conveyorized Equipment Offers Flexibility in Treatment of Small and Medium-size Components



The machine shown is set up as a self-contained unit, but is readily adaptable for incorporation into a flow line

PAINT spraying of small and medium-size parts in mass-production systems frequently involves awkward manhandling during the spraying operation. This, of course, is partly because of the employment of only one spray gun, so that the operator has to turn the workpiece to ensure complete coverage, and partly as a consequence of the nature of the hooks or holding devices, which frequently allow small uncontrollable movements to develop while the workpiece is being turned. On the new conveyorized automatic spraying machine recently announced by Alfred Bullows and Sons Ltd, Walsall, Staffs, there is provision for more than one gun to be operated at a time; better coverage can be afforded, and the need for turning the workpieces is thereby obviated, and they therefore remain steady while being sprayed.

Each basic unit of the spraying machine consists of a conveyor track, a spraying station and a downdraught exhaust system. According to requirements, the system can be augmented by the addition of more track and spraying stations either initially or when the need arises. A basic spraying station consists of one spray gun, a gun traverse mechanism, and its mounting brackets; the standard conveyor chain, on to which the workholders fit, is approximately 25 feet long. Chains with pitches of 2 in, 3 in, 4 in or 6 in can be supplied, and the choice depends on the rate of production and the size of workpieces; the standard machine system has a driving sprocket of approximately 28 in diameter, but a 42 in diameter sprocket is available for applications involving the spraying of components the major overall dimensions of which are more than 12 in.

In operation, the conveyor track is moving the whole time, and spray guns have a reciprocating motion as they follow their targets. The components are loaded on to the workholders at one end of the machine and can be unloaded at the same place after painting is completed. As an alternative to this endless chain arrangement, a floor-mounted conveyor is available which carries the work along to a stoving oven, or to an unloading station if air-drying materials are used. Infinitely variable speed drives are available.

The spray guns are mounted on hydraulically operated arms, and their movements are governed by cams, of which there is a standard range. When a change to workpieces of a different size is called for, a simple interchange and adjustment of cams enables a new setting to be rapidly effected. Spraying time can similarly be adjusted. Compressed air at 60 lb/in^2 is required for the operation of the spray guns and the working of their valves.

A relief valve is incorporated in the hydraulic system, so that no damage will ensue if the gun motion is impeded or jammed; in the event of any such mishap, the hydraulic system re-adjusts itself without disturbing the gun settings. A mechanical memory device is available, as an optional extra, which automatically sends a signal to the machine when workholders are not loaded, and thereby saves paint and avoids the repeated painting of unloaded workholders. Typical rates of production for workpieces of various sizes are: 30 to 60 per min for cylindrical objects up to 4 in diameter and 8 in high, 10 to 25 per min for rectangular components and small pressings, 5 to 10 per min for larger and more complex objects.

The downdraught exhaust system has vertical ducting, opposite the spraying station, and paint-laden air is carried down to a separator and then out to atmosphere. There is a system of circular baffles incorporated in this separator.

Book Reviews

Brief Comments on Recent Publications of Interest to Automobile Engineers

Engineering Design with Rubber

By A. R. Payne, B.Sc., A.Inst.P., A.I.R.I. and J. R. Scott, Ph.D., M.Sc., F.R.I.C., F.Inst.P., F.I.R.I.

London: MACLAREN AND SONS LTD, Maclaren House, 131 Great Suffolk Street, S.E.1. 1960. $8\frac{3}{4} \times 5\frac{1}{2}$. 256 pp. Price 50s.

An important requirement for the proper use of rubber as an engineering material is, of course, a thorough understanding of its behaviour under rapidly changing stresses such as are induced by either vibrations or shock. This behaviour, of course, varies with temperature and frequency or rate of deformation. Several years ago, the Research Association of British Rubber Manufacturers began to study the properties of rubber under dynamic conditions, and the methods of measuring those properties. Subsequently, a three-day symposium, under the title "Dynamic Design with Rubber", was held at the Shropshire Adult College, near Shrewsbury, in October and December 1958. The work under review is a permanent record of the material presented at this symposium and, in addition, it incorporates material to make it a fuller account of the whole subject and to form a practical manual for the guidance of engineers and rubber technologists. The aim has been at presenting sufficient of the basic physical properties of rubber to enable the engineer, unfamiliar with rubber technology, to appreciate the essential characteristics of this material. The subject is dealt with in such a way that only a modicum of mathematics is required.

The chapter headings are as follows: The rubber-like state; Dynamic and related time-dependent properties of rubber; Other properties relevant to engineering design; Dynamic and related test methods and machines; Test methods other than dynamic; Force/deformation relationships in rubber units; Resonance and transmissibility; Some practical design details; The use of rubber in engineering; Collaboration between the engineer and the rubber technologist. At the end of the book the following appendices are given: British and U.S. standard test methods for rubber; British and U.S. standards for natural and synthetic rubber compounds; Properties of vulcanised natural and synthetic rubbers.

Progress in Metallurgical Technology

London: ILIFFE BOOKS LTD, Stamford Street, S.E.1. 1960. $8\frac{3}{4} \times 5\frac{1}{2}$. 147 pp. Price 32s 6d.

Every year since 1947, the Institution of Metallurgists has held a refresher course for its members, during which four leading authorities survey the present state of knowledge in relation to a particular aspect of metallurgy. Originally these papers were republished in book form solely for the benefit of Institution members, but the information they contained was considered far too valuable for only a limited circulation. Therefore, in conjunction with the present publishers, it was arranged that all papers read at refresher courses from 1956 onwards should be made available to a wider public. The response to the publication of the first three volumes under this scheme was very gratifying, and it is felt that the demand for this fourth volume will certainly be at least as great.

At the 1959 refresher course, the current position of metallurgical technology was reviewed, and recent developments and trends discussed. In the first paper in this volume, Dr. John Taylor deals with modern developments in the production of iron and steel, including the revolution that is now taking place in steel-making practice, as a result of the advent of so-called tonnage oxygen. Mr. Bradshaw, in the paper which follows, outlines the various methods now in use for the extraction and refining of non-ferrous metals, and gives a detailed description of the newer processes. Amongst other things, he deals with autogenous grinding, hydrocyclone classification and fluidized bed roasting. He also discusses hydro-metallurgical techniques for the exploitation of low grade ores and the influence of ion exchange and solvent extraction processes. Another section covers developments in pyrometallurgy. In the third paper Dr. Robiette deals with the melting of ferrous and non-ferrous metals, and shows that although methods have not changed greatly throughout the years, the introduction of improved equipment and a greater degree of mechanization have led to increased efficiency and the production of purer metals. Finally, Dr. D. V. Atterton, in his paper on casting, shows how it has been possible to attain at the same time both an increased rate of production and a high level of quality.

The contents are as follows. Paper 1: Modern Developments in Iron and Steel Production, by John Taylor, M.Sc., Ph.D., F.I.M., Principal Lecturer in Metallurgy at the Royal College of Science and Technology, Glasgow. Paper 2: Extraction and Refining of Non-Ferrous Metals, by A. V. Bradshaw, B.Sc., A.R.S.M., F.I.M., Lecturer in Metallurgy at the Imperial College of Science and Technology, London. Paper 3: Melting of Ferrous and Non-Ferrous Metals, by A. G. Robiette, D.Sc., F.I.M., Metallurgical Consultant. Paper 4: Casting of Ferrous and Non-Ferrous Metals, by D. V. Atterton, M.A., Ph.D., A.I.M., Managing Director of Foundry Services Ltd.

Workshop Engineering Practice

By H. G. Rider

London: ILIFFE BOOKS LTD, Stamford Street, S.E.1. 1960. Volume I, $8\frac{1}{4} \times 5\frac{1}{4}$. 150 pp. Price 9s 6d. Volume II, $8\frac{1}{4} \times 5\frac{1}{4}$. 138 pp. Price 9s 6d.

This series of books on various aspects of workshop engineering is intended for young people taking these subjects at Secondary Modern and Junior Technical Schools, or studying for the craft examinations of the City and Guilds of London Institute. It has been specially prepared to present the subjects in the most easily understandable way: great pains have been taken to make every point clear, in picture form wherever possible, especially where a sequence of operations has to be demonstrated. These two volumes contain over 740 drawings in their 288 pages and, to enable the fullest advantage to be taken of the visual method that is the essence of the series, sets of coloured filmstrips based on these books have been distributed by Film Strip and Slide Distributors Ltd, 3a Harrington Road, London, S.W.7. The author of these first two volumes is Chief Instructor in Workshop Engineering, Borough Polytechnic, London. Other volumes in the series will cover: Sheet Metal Work, Materials, Welding, and Foundry Work.

The list of contents is as follows. Volume 1, Fitting: Introduction to fitting; Saws and shears; Files and filing; Scrapers and scraping; Cutting screw threads and reaming holes; Measuring-instruments; Marking out; The drilling machine; Practical exercise in fitting; Safety in the workshop; Index. Volume II, Lathework: The lathe; Lathe tools and cutting speeds; Measuring-instruments; Marking out; Practical exercise in plain turning between centres; Practical exercise in turning a bush from a bar; Practical turning exercises using chucks and mandrel; Face-plate work; Tapers; Safety in the workshop; Index.

Heat Transfer Engineering

By H. Schenck

London: LONGMANS, GREEN AND CO. LTD, 6 and 7 Clifford Street, W.1. 1960 $8\frac{3}{4} \times 5\frac{1}{2}$. 314 pp. Price 28s.

The author of this book is Assistant Professor of Mechanical Engineering in the Clarkson College of Technology. His aim apparently has been at producing a textbook suitable for undergraduates. Starting from the basic principles of the subject, the author deals in turn with each of the modes of thermal energy transfer. He then goes on to discuss systems involving two or more of these mechanisms, and finally describes whole transmission systems comprising several components. In view of the importance of heat exchangers in modern industrial practice, the author has given detailed consideration to their theory and design. The last chapter deals with some of the principles of experimental and test work.

At the end of each chapter there is a selection of problems

drawn from a wide range of up-to-date industrial applications, including nuclear reactors and solar energy installations, and answers are supplied at the end of the book. The work in each chapter is, of course, illustrated by worked out examples. The author has assumed that the reader is familiar with concepts such as the Fanning friction factor, viscosity, and the principles of dimensional analysis as applied to fluid systems. Sufficient examples are given to allow the reader who is not strong in dimensional methods to grasp the techniques, at least so far as they apply to heat transfer. The formal solution of partial differential applications has been replaced wherever possible by approximate analytic solutions involving elementary differentials. This has the considerable advantage of enabling the reader to view clearly the physical rather than the purely mathematical aspects of heat transfer systems.

The headings of the chapters are as follows: Heat transfer—a summary; Steady-state conduction heat transfer; Heat transfer by natural convection; Heat transfer by forced convection; Radiation heat transfer; Unsteady-state conduction with convection; Combined heat-transfer problems; Boilers and condensers; Heat exchangers; Some important thermal systems; Heat-transfer testing. Finally, there is an appendix containing data on the properties of air, saturated steam and helium, gases and vapours, and of saturated water. There is a table of conversion factors for heat units; and, in addition, nomograms for continuity, Reynolds number for round tubes, Stanton number and fin parameter, and a function scale for the effectiveness of thin straight fins of constant cross section.

From Engines to Autos

By E. Diesel, G. Goldbeck and F. Schildberger, translated by P. White

Chicago: HENRY REGNERY CO, Chicago 4, Illinois, U.S.A. 1960. $8\frac{1}{2} \times 5\frac{1}{2}$. 302 pp. Price $6.00.

This is an English translation of the book "Vom Motor Zum Auto: Fünf Männer und ihr Werk", which was reviewed in the December 1958 issue of *Automobile Engineer*. As we discovered in the course of the preparation of our Jubilee Issue, which was published in June 1960, a great deal of valuable historical material is being lost as the older generation of those who played such a great part in the automobile industry are disappearing. In fact, unless efforts are made very soon to compile records, there will be large gaps in the history of the motor vehicle.

The work under review is particularly valuable as a record of five pioneers of the motor industry. These men are Nikolaus August Otto, Gottlieb Daimler, Karl Benz, Robert Bosch and Rudolph Diesel. The book is a saga of the development of a great industry from the designs of these men, their heartbreaking failures, the determination to surmount the obstacles and the personal tragedies that they faced in that stormy epoch when fortunes were won or lost, in some instances with devastating suddenness and in the course of a few hours.

Untersuchung von Kraftfahrzeng-Auspuffgasen auf gesundheitsschädliche Substanzen und deren Beseitigung durch Filter. (Investigation of Exhaust Gases Regarding Substances Injurious to Health and their Elimination by Filters.) Deutsche Kraftfahrtforschung und Strassenverkehrstechnik, No. 126.

In German, by A. Reuter, Dr., R. Marterstock and K. Jahne.

Düsseldorf: VDI-VERLAG G.m.b.H, 1959. $11\frac{3}{4} \times 8\frac{1}{4}$. 25 pp. Price D.M. 19.

Increasing incidence of lung cancer has focused attention on not only the effect of cigarette smoke but also 3·4 benzpyrene, the cancerogenous action of which has been investigated particularly in the U.S.A. The report under review deals with the work carried out at the Battelle Institute at Frankfurt. In the first section, Dr. Reuter considers the possibility of extracting 3·4 benzpyrene, with regard to the nature of the substance in which it is included, and with particular reference to diesel exhaust gases. In the second part, Marterstock and Reuter deal with the quantitative determination of the 3·4 benzpyrene content and the comparison between this content and the exhaust smoke intensity of diesel engines. They have come to the conclusion that the formation and breaking up of benzpyrene in the exhaust can be influenced by design features.

Next, Reuter, Jahne and Marterstock deal with the analysis of soot in various exhaust gases, with particular reference to the presence of cancerogenous substances other than 3·4 benzpyrene. While it has been established that diesel exhaust also contains pyrene, fluoranthene, 1·12 benzperylem anthracene and 11·12 benzfluoranthene, it is known that pyrene, fluoranthene and anthracene are not cancerogeneous. As the result of their work, the authors suggest further research regarding the effects of fuel composition, the exhaust and fuel injection systems and of engine condition and mileage with regard to the generation of 3·4 benzpyrene.

The last part of the report, by Marterstock and Reuter, deals with the possibility of using exhaust filters. It would appear that Meerschaum filters can be effective so far as lead absorption is concerned, but further investigation will be required. While the report does not make definite recommendations, the results of these complex investigations are stimulating in directing thoughts to the importance of a problem of which undoubtedly more will be heard in the not too distant future.

Beanspruchung und Belastbarkeit von Kupplungsbefestigungsvorrichtungen an Lastkraftwagen. (The Stressing and Load Capacity of Coupling Devices of Lorries.) Deutsche Kraftfahrtforschung und Strassenverkehrstechnik, No. 124.

In German, by E. Essers, Prof. Dr. Ing. and H. Kreiskorte, Dr. Ing.

Düsseldorf: VDI-VERLAG G.m.b.H, 1959. $11\frac{3}{4} \times 8\frac{1}{4}$. 46 pp. Price D.M. 24.80.

The use of heavy lorries in conjunction with one or two, four- or six-wheel trailers has become common practice in many Continental countries since the war. However, the increasing number of serious accidents caused by failures of couplings or their attachments has made it necessary to investigate the nature and magnitude of forces encountered in service as well as the resultant stresses at the point of attachment of the coupling to the chassis. The work dealt with in the report under review was carried out, at the Institute of Vehicle Engineering and Internal Combustion Engines of the Technical High School, Aachen, at the request of the German Federal Ministry of Transport. Its object was to obtain fundamental data for acceptance and type tests of vehicle components.

In the report is a statistical evaluation of coupling load records obtained over a considerable mileage, the calculation of the strength of the chassis members that must carry the coupling loads, and the resultant stress distribution pattern. With regard to the stress distribution, a worked out example illustrates the procedure. Many rig tests were devoted to the experimental determination of the stress distribution, under static and dynamic loading, among the chassis members. The fatigue characteristics of the designs concerned received particular attention. As a result of these investigations, the authors have been able to recommend the most desirable design features, so far as the attachment of the coupling carrying cross members to the chassis is concerned, and they support their recommendations with the results of tests carried out on an assembly made on the lines they suggest.

The report concludes with suggestions regarding a comprehensive procedure for testing coupling attachment components. As the authors rightly point out, before such a test schedule is made compulsory, its suitability should be verified on a broader basis than has so far been possible. It is obvious from this short review of the subject matter, that the report will be of considerable interest and assistance to designers and operators of heavy commercial vehicles required to take heavy trailing loads. A careful study of it will be of benefit in respect of obtaining a higher standard of safety and reliability.

Fahrtrichtungshaltung und Fahrstabilität von vierrädrigen Kraftfahrzeugen. (Stability of Four-Wheel Motor Vehicles.) Deutsche Kraftfahrtforschung und Strassenverkehrstechnik, No. 135.

In German, by M. Mitschke, Dr. Ing.

Düsseldorf: VDI-VERLAG G.m.b.H, 1960. $11\frac{3}{4} \times 8\frac{1}{4}$. 28 pp. Price D.M. 19·80.

A research programme organized by the German Ministry of Transport, in connection with road safety, includes studies of vehicle design factors. The work under review, which is part of this programme, has been carried out by the Institution of Road Vehicle Technology, of the Carolo-Wilhelmina Technical High School, Braunschweig. Maintenance of a steady course and the stability of road vehicles during manoeuvring are, of course, essential so far as safety is concerned, and this accurate and detailed treatise on this subject is therefore most valuable.

In the work, the available published material has been summarized and some additions made to the previously formulated theories. Another useful feature is the illustration of problems by means of calculated examples. Tyre characteristics are dealt with in a short section, and there are also some tables containing vehicle and suspension performance data that is not widely known. Front-wheel, rear-wheel and all-wheel steering systems are discussed. Another subject that is covered is stability in side winds, both in relation to the steering system and under conditions when the steering wheel is in its mid-travel position.

NEW PLANT AND TOOLS

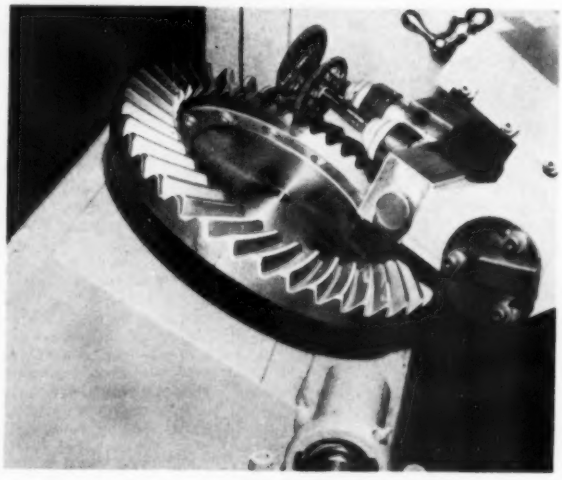
Recent Interesting Developments in Production Equipment

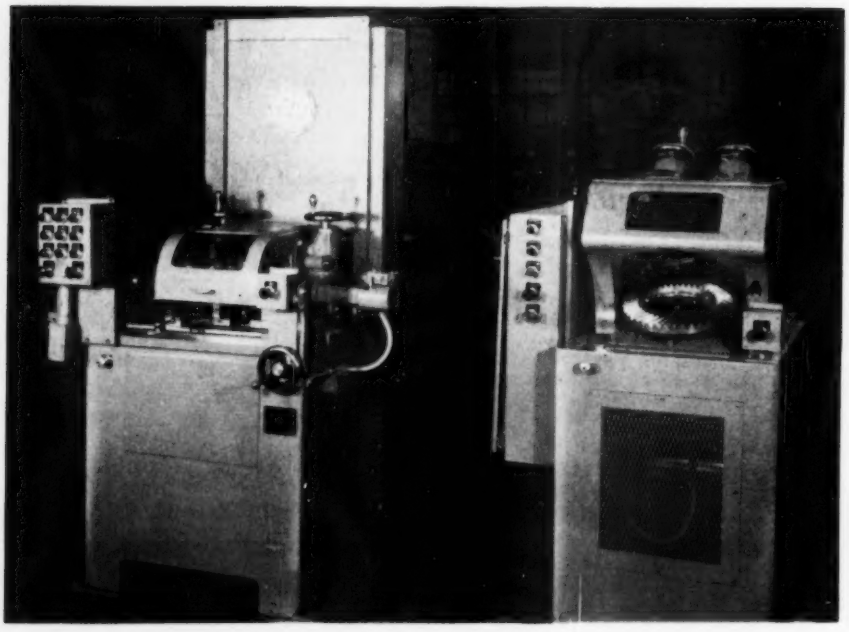
A TWIN-SPINDLE, automatic, high-speed grinder for simultaneous deburring and chamfering of gear teeth has been developed by the Michigan Tool Co, Detroit, U.S.A. The agents in Great Britain are Gaston E. Marbaix Ltd, Devonshire House, Vicarage Crescent, London, S.E.11. Two variants of the machine are available: in one, the axis of the workpiece is horizontal, so that components such as gear clusters can be treated, and in the other, it is in a vertical plane so that crown wheels or similar gears can be accommodated. In both types of machine, the driving of the grinding wheel spindles and movements of the work platform are effected pneumatically, whereas a fractional h.p. electric motor rotates the workpiece.

In the case of a crown wheel, after the workpiece has been loaded, the platform tilts up to its operational position and the rotation begins. The two grinding wheels descend until they contact the inner and outer ends respectively of the gear teeth, and deburring and chamfering take place as the wheels ride up and down the tooth profiles. A counter-balance weight embodied in each spindle assembly provides the appropriate pressure between the grinding wheel and gear, and the chamfer depth is regulated by controlling the number of rotations of the workpiece. When the pre-set number of rotations is complete, the grinding wheels lift clear, the platform is lowered to the unload position, and the workpiece stops rotating. All of these operations are automatic. Where expedient, pneumatic clamping devices can be used to hold the workpiece.

The cycle time varies from 20 sec to 60 sec per gear, according to size of gear and depth of chamfer required. Provision is also made for adjustment of the speed of rotation, while the grinding wheels are driven at 17,000 r.p.m. Gears from 3 in to 13 in diameter can be accommodated on standard machines, but other models exist which can accept components up to 20 in diameter. Grinding wheels from $1\frac{1}{4}$ in to 3 in diameter to suit the gear size can be obtained, and during production runs the two wheels are interchanged at approximately four-hour intervals so that wear on both sides is equalized. To accommodate gears of different sizes, the wheel spindle positions are fully adjustable. High quality fibre, in the material of the grinding wheels, renders them shatter proof.

Protection for the machine operators is afforded by





Above: Deburring and chamfering of gear teeth—crown wheel being deburred

Left: Two variants of gear deburring and chamfering machines. In the machine on the left a gear cluster is being treated; on the right a crown wheel is ready to be worked

(Gaston E. Marbaix Ltd)

transparent hoods; exhaust outlets, suitable for coupling to a dust extractor system, are fitted. A safety feature is incorporated in the starter-button assembly, making it impossible to start the grinding wheel motors accidentally.

Gas dryers

Recently introduced by AEI-Birlec Ltd, Tyburn Road, Erdington, Birmingham 24, is a series of dryers designated the BZ series Autosorbers. The new equipment is of the fully automatic dual tower type, intended for the continuous drying of compressed air and other gases; any of the commercially available adsorbents, such as activated alumina, molecular sieves, silica gel and Sorbead, can be used. Another application for this equipment is the adsorption of carbon dioxide.

One of the aims in the preparation of the new designs has been compactness, and 50 per cent reductions in floor area required are claimed. The dryers have been sized to provide capacities most frequently demanded by customers, and extensive experimental work on process capacity and pressure drop under a range of flow conditions has preceded the formulation of the designs now in production. New methods of heating and cooling the adsorbers during the reactivation period are the subjects of patent applications, as are methods of economizing in respect of the flow of purge gas.

Typical capacity figures for the dryers are in the range 25-500 s.c.f.m. at 100 lb/in² or 5-100 s.c.f.m. at atmospheric pressure. The more popular sizes are available from stock, as standard units fitted for electrical reactivation, and by simple modification these units can be converted for steam reactivation for flame-proof operation. Optional extras are available for purge re-use.

BZ series Autosorber, for automatic and continuous drying of gases
(AEI-Birlec Ltd)

Below: The single blade of the Mapal reamer is not removed during re-sharpening
(Monks and Crane Ltd)

High-speed drum sanders

Centrifugal force is employed for locking the abrasive band in position in the new range of drum sanders recently introduced for portable tools by B. O. Morris Ltd, Morrisflex Works, Briton Road, Coventry. Angled slots in the central rubber drum provide this feature during operation, and also allow cooling air to circulate behind the abrasive band. Changing of bands is effected quickly and easily, because the locking force is not present when the drum is stationary. An additional feature is that the working face of the band remains true after the band has been fitted, so that the whole of the abrasive surface can be utilized. Three sizes of drums are available: 1 in diameter × 1 in wide × ¼ in shank, 2 in diameter × 1 in wide × ¼ in shank, and 4 in diameter × 1½ in wide × ⅜ in shank.

Drum sander
(B. O. Morris Ltd)

Adjustable hand-reamer

In the precision-ground chromium-plated body of the Mapal hand-reamer there is only one blade. Among the advantages said to result from this departure from conventional practice are obviation of the chatter marks which of course are sometimes associated with adjustable reamers, and the ability to adjust the setting while a hole is being reamed. Adjustment is effected by clockwise turning of the scale lever at the centre of the handle.

Eight different sets of reamers are available, and a range of sizes from 0·315 in to 2·5 in is thereby obtainable. Each reamer is adjustable from its nominal major diameter down to a dimension 10 per cent less than this, which means that fewer reamers are needed to cover a given range of sizes than would be the case with other adjustable reamers. The claim is made that the life of the Mapal hand-reamer is at least ten times that of normal hand-reamers.

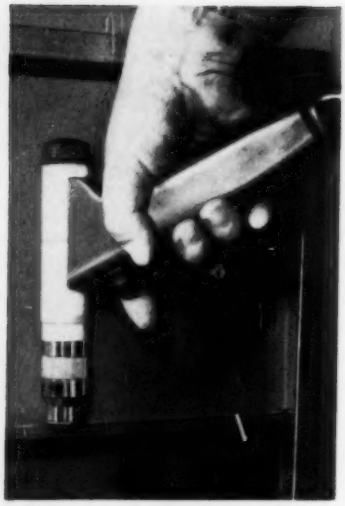
Re-sharpening is done on a surface grinding machine and does not involve removal of the blade from the reamer body. The blade is ground longitudinally while the body rests on a flat provided for the purpose opposite the blade. Retention of accuracy and parallelism are thereby ensured.

Holes in thin material can be precision finished, provided the hole depth is more than ¼ of the reamer diameter. The reamer can be used on most ferrous and non-ferrous metals, and on plastics materials. British distributors of the Mapal hand-reamer are Monks and Crane Ltd, Garretts Green Lane, Birmingham 33.

Spot-welding torch

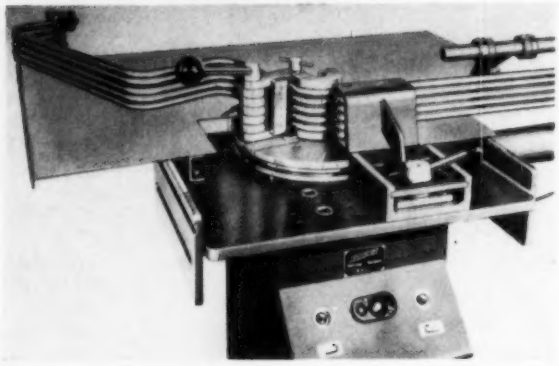
A new spot-welding torch, designated the SW. 300 Argonarc Spot Welding Torch, was shown for the first time at the Farnborough Air Show in September last. It is a product of the British Oxygen Co. Ltd, Bridgewater House, Cleveland Row, St. James's, London, S.W.1, and will be marketed shortly. The chief point of interest is the fact that, for the operation of this torch, access to only one side of a joint is required. The work is, of course, earthed by a clip on a flexible cable.

Interchangeable nozzles are available for making spot



Spot-welding torch
(B.O.C. Ltd)

Below: Semi-automatic tube bender
(Addison Tool Co. Ltd)



welds in horizontal or vertical positions, on narrow flanges, or on 90 deg exterior corner-joints. It is interesting to note that spot welds can be made with one hand, and that unskilled labour can be employed. If necessary, the equipment can be made mobile.

The torch, which is water-cooled, can carry a current of 300 amps, and this is controlled by a button type micro-switch in the handle. Incorporation of a back-entry collet means that quick adjustment or replacement of electrodes can be effected without the need for removing the ceramic adaptor or argon shield. Welding conditions are pre-set, and the process, which is semi-automatic, calls for only occasional replacement or re-setting of the tungsten electrode.

Development work has indicated that the process can be used on commercially pure aluminium and on some aluminium alloys. Joints can be made with mild steel, alloy steel and titanium, and shear values compare favourably with those obtained from resistance welding. A good surface finish is claimed, needing little or no grinding or polishing.

Mechanical shaft seals

These seals, introduced by Crane Packing Ltd, of Slough, are suitable for applications involving a wide range of liquids and gases of a non-corrosive or mildly corrosive nature. There are two versions, both of which have their sealing surfaces normal to the shaft axes. The basic difference between the two is that type 106 is shaft mounted and rotates with the shaft, whereas type 106A is a press-in version that remains stationary and is not in contact with the shaft. Type 106 units are available in a range of sizes for shafts up to 1 in diameter; type 106A units, first designed for use as water pump seals for car engines, are available in sizes up to $\frac{3}{4}$ in diameter.

As can be seen from the accompanying illustrations, contact between the two sealing surfaces is maintained by a spring that is concentric with the shaft, and flexibility is obtained by the incorporation of a synthetic rubber bellows, with the result that any wear is compensated for and a degree of end-play and malalignment can be tolerated. In most applications the precision lapped sealing face mates with a floating seat that is mounted on a synthetic rubber ring fixed, as appropriate, on the shaft or in a housing surrounding the shaft. In the case of a motor car water pump, the sealing surface can be on the hub of the impeller.

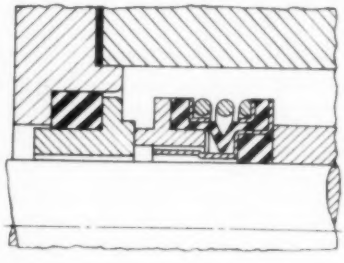
A maximum pressure of 75 lb/in² is specified for these seals, and it is claimed that their ability to run at high speed and absorb shaft vibrations is of a high order. In normal conditions shaft speeds of up to 3,000 r.p.m. can be tolerated by the type 106 rotating unit which is a seal for applications such as fuel oil, hydraulic and other positive displacement pumps, deep and shallow well jet pumps, refrigeration compressors, small centrifugal water pumps, and agitator shafts. Speeds up to 5,000 r.p.m. are tolerated by the type 106A unit. The flexible member in these seals is of high grade synthetic rubber, the sealing face is carbon or Teeplelite, and the floating seat is of cast iron, bronze or Ni-resist.

Semi-automatic tube bender

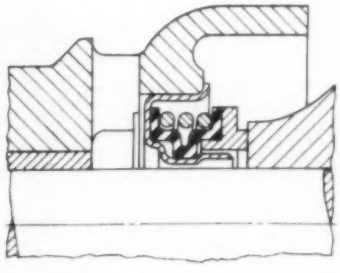
The Bahler BB. 30 tube bending machine is manufactured in Switzerland and marketed by The Addison Tool Co. Ltd, Addison House, 28, Marshalsea Road, London, S.E.1. Incorporated in this machine are features that provide for the bending of tubes either singly or up to 5 at a time. The bending speed is 6 r.p.m. and power is provided by a geared brake motor working at standard a.c. voltages; alternatively, a pole-change a.c. motor is available which provides bending speeds of either 6 or 12 r.p.m.

With standard tooling, tubes up to 1·25 in outside diameter and $\frac{1}{8}$ in wall thickness can be bent to radii from 1·25 in to 6 in, with 180 deg sweep; tube lengths of up to 6 ft are accommodated on the mandrel-bar support, and an extension

Type 106 mechanical shaft seal
(Crane Packing Ltd)



Type 106A seal, originally designed for use as a water pump seal for car engines



enables tubes of 20 ft length to be supported. Special tools are available for the manufacture of parallel rising coils, flat coils and closed rings, and successive bends can be made in the same or different planes. With the aid of special tools it is possible in most cases to bend to radii less than twice the diameter of a tube.

The automatic switch gear can be set to any desired bending angle; moreover, left-and-right bends can be made, and various sections and hollow profiles can be bent without filling. Larger versions of this machine are available which can accommodate tubes of diameters up to 4 in, and, for mass production, fully automatic machines can be designed using the BB. 30 machine as a basis.

Rising-blade sawing machine

One of the most interesting features of the recently introduced Cefmo AC85 sawing machine is the incorporation of a rotating table. This means that long workpieces do not need to be moved around between cuts of different mitre angles, and workshop space is thereby saved. The machine, which is designed to cut bars, tubes and light sections, is manufactured by the Cefmo Co, of France, and the British agents are The Addison Machine Tool Co. Ltd, Addison House, 28 Marshalsea Road, London, S.E.1.

An electric motor that develops 1½ h.p. at 1,500 r.p.m. drives a 12 in. diameter saw blade that is mounted on a rigid central column. Cutting is done from the bottom upwards, and the saw is brought up from below the table to its required height by means of a hand-operated lever on the side of the machine. Cuts are made without run-out, therefore, and maximum use of the blade diameter can be made for slotting. Rapid cutting operations are thus obtainable.

A screw clamp holds down the workpiece, which is located laterally by adjustable guide plates. Other clamps are provided to fix the turntable position when the angle of cut or mitre has been selected. Cutting lubricant is supplied by an electric pump, through a flexible pipe.

Tube joints

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As can be seen from the illustration, in which are shown double tee and tee cross connections, neatness of the joint is one of the features of this method of construction. Equipment such as racks, trestles, benches, stands, ladders, handrails and small grandstands can all be made, for either applications in factories or the construction of proprietary tubular units. The joints are for use with 16 S.W.G. resistance welded tube only, and those currently in production are designed to fit 1¼ in outside diameter tubing. Joints for 1 in outside diameter tube will be in production shortly, and other sizes will follow.

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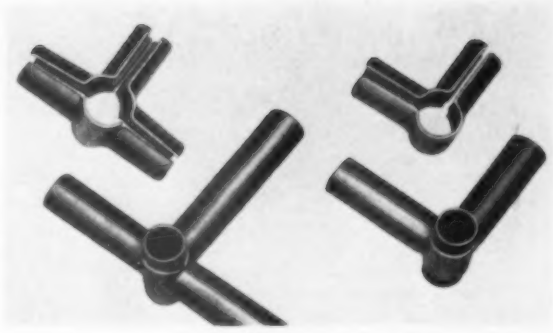
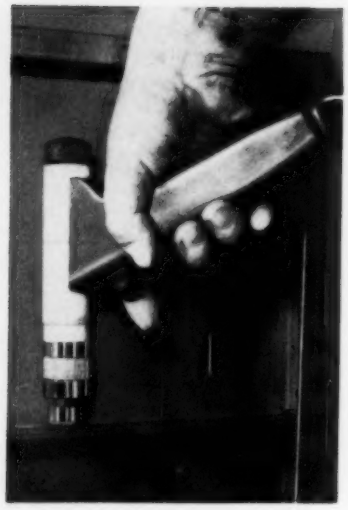


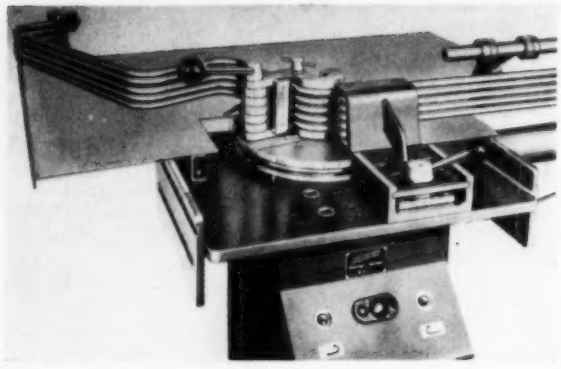
CLINCH permanent tube joints
(Access Equipment Ltd)

Medium duty spot welder, front and rear views
(Electro Mechan-Heat Ltd)



Spot-welding torch
(B.O.C. Ltd)

Below: Semi-automatic tube bender
(Addison Tool Co. Ltd)



welds in horizontal or vertical positions, on narrow flanges, or on 90 deg exterior corner-joints. It is interesting to note that spot welds can be made with one hand, and that unskilled labour can be employed. If necessary, the equipment can be made mobile.

The torch, which is water-cooled, can carry a current of 300 amps, and this is controlled by a button type micro-switch in the handle. Incorporation of a back-entry collet means that quick adjustment or replacement of electrodes can be effected without the need for removing the ceramic adaptor or argon shield. Welding conditions are pre-set, and the process, which is semi-automatic, calls for only occasional replacement or re-setting of the tungsten electrode.

Development work has indicated that the process can be used on commercially pure aluminium and on some aluminium alloys. Joints can be made with mild steel, alloy steel and titanium, and shear values compare favourably with those obtained from resistance welding. A good surface finish is claimed, needing little or no grinding or polishing.

Mechanical shaft seals

These seals, introduced by Crane Packing Ltd, of Slough, are suitable for applications involving a wide range of liquids and gases of a non-corrosive or mildly corrosive nature. There are two versions, both of which have their sealing surfaces normal to the shaft axes. The basic difference between the two is that type 106 is shaft mounted and rotates with the shaft, whereas type 106A is a press-in version that remains stationary and is not in contact with the shaft. Type 106 units are available in a range of sizes for shafts up to 1 in diameter; type 106A units, first designed for use as water pump seals for car engines, are available in sizes up to $\frac{3}{4}$ in diameter.

As can be seen from the accompanying illustrations, contact between the two sealing surfaces is maintained by a spring that is concentric with the shaft, and flexibility is obtained by the incorporation of a synthetic rubber bellows, with the result that any wear is compensated for and a degree of end-play and malalignment can be tolerated. In most applications the precision lapped sealing face mates with a floating seat that is mounted on a synthetic rubber ring fixed, as appropriate, on the shaft or in a housing surrounding the shaft. In the case of a motor car water pump, the sealing surface can be on the hub of the impeller.

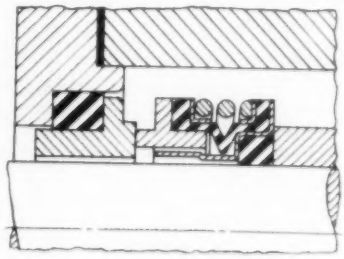
A maximum pressure of 75 lb/in² is specified for these seals, and it is claimed that their ability to run at high speed and absorb shaft vibrations is of a high order. In normal conditions shaft speeds of up to 3,000 r.p.m. can be tolerated by the type 106 rotating unit which is a seal for applications such as fuel oil, hydraulic and other positive displacement pumps, deep and shallow well jet pumps, refrigeration compressors, small centrifugal water pumps, and agitator shafts. Speeds up to 5,000 r.p.m. are tolerated by the type 106A unit. The flexible member in these seals is of high grade synthetic rubber, the sealing face is carbon or Teeplelite, and the floating seat is of cast iron, bronze or Ni-resist.

Semi-automatic tube bender

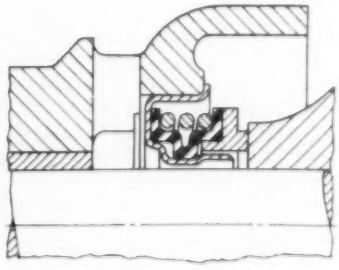
The Bahler BB. 30 tube bending machine is manufactured in Switzerland and marketed by The Addison Tool Co. Ltd, Addison House, 28, Marshalsea Road, London, S.E.1. Incorporated in this machine are features that provide for the bending of tubes either singly or up to 5 at a time. The bending speed is 6 r.p.m. and power is provided by a geared brake motor working at standard a.c. voltages; alternatively, a pole-change a.c. motor is available which provides bending speeds of either 6 or 12 r.p.m.

With standard tooling, tubes up to 1·25 in outside diameter and $\frac{1}{8}$ in wall thickness can be bent to radii from 1·25 in to 6 in, with 180 deg sweep; tube lengths of up to 6 ft are accommodated on the mandrel-bar support, and an extension

Type 106 mechanical shaft seal
(Crane Packing Ltd)



Type 106A seal, originally designed for use as a water pump seal for car engines



enables tubes of 20 ft length to be supported. Special tools are available for the manufacture of parallel rising coils, flat coils and closed rings, and successive bends can be made in the same or different planes. With the aid of special tools it is possible in most cases to bend to radii less than twice the diameter of a tube.

The automatic switch gear can be set to any desired bending angle; moreover, left-and-right bends can be made, and various sections and hollow profiles can be bent without filling. Larger versions of this machine are available which can accommodate tubes of diameters up to 4 in, and, for mass production, fully automatic machines can be designed using the BB. 30 machine as a basis.

Rising-blade sawing machine

One of the most interesting features of the recently introduced Cefmo AC85 sawing machine is the incorporation of a rotating table. This means that long workpieces do not need to be moved around between cuts of different mitre angles, and workshop space is thereby saved. The machine, which is designed to cut bars, tubes and light sections, is manufactured by the Cefmo Co, of France, and the British agents are The Addison Machine Tool Co. Ltd, Addison House, 28 Marshalsea Road, London, S.E.1.

An electric motor that develops 1½ h.p. at 1,500 r.p.m. drives a 12 in. diameter saw blade that is mounted on a rigid central column. Cutting is done from the bottom upwards, and the saw is brought up from below the table to its required height by means of a hand-operated lever on the side of the machine. Cuts are made without run-out, therefore, and maximum use of the blade diameter can be made for slotting. Rapid cutting operations are thus obtainable.

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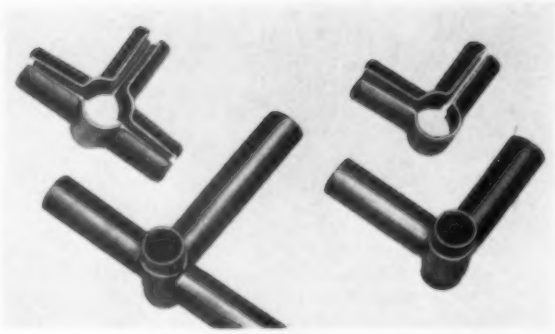


CLINCH permanent tube joints
(Access Equipment Ltd)

Medium duty spot welder, front and rear views
(Electro Mechan-Heat Ltd)

Medium-duty spot welder

Electro Mechan-Heat Ltd, Lower Teddington Road, Kingston-upon-Thames, Surrey, have introduced the Type M50 Mk III medium-duty spot welder, designed primarily for use with 18-22 S.W.G. bright mild steel. The machine, which is capable of 300 spot welds per minute, is suitable for stitch welding, and will be of particular value in applications where high speeds of spot-welding are desired. It has a nominal rating of 50 kVA at 50 per cent duty cycle, and is normally supplied to operate on any two phases of a 400/440 volt 50 c/sec 3-phase a.c. supply.

Welding pressure at the electrode tips is approximately 1,100 lb/in^2, and is provided by a 5 in diameter pneumatic cylinder working at a standard air line pressure of 80 lb/in^2. The vertical slideways for the welding head are of knife edge section, and the rollers that run on them have V-section peripheries; contact area is thus very small, and there is minimum resistance to vertical movement. As an optional extra there is a special high lift air cylinder which gives the electrode tips a maximum of 5 in lift for insertion of workpieces, and then returns them to the normal gap ready for the welding operation.

On the standard machine, a single pedal controls the welding operation, but two pedals are provided when the high lift cylinder is incorporated; the second of these brings the welding head down to the normal spot welding position.

Both electrode holders are clamped in horizontal arms, so that vertical adjustment is available, and the lower arm can be raised or lowered 8 in on its own slideway. These arms, fixed in their clamps, can be swung about a vertical axis to 90 deg on either side of the normal working position, to facilitate the welding of long sections. The machine is equipped with a standard Electro Mechan-Heat stacked-core transformer, and the welding cycle is controlled by a three- or four-stage electronic timer, in conjunction with an ignitron contactor. Squeeze, weld, forge and off time can each be varied between 3 and 70 cycles, based on a 50 c/sec a.c. supply, by means of stepless controls.

The "Speedy" Moisture Tester

A Portable, Self-contained, Direct-reading Instrument for Use in the Workshop by Unskilled Personnel

MOST materials contain water in proportions that can vary over fairly wide limits and these proportions can change rapidly under the influence of environmental conditions. The physical properties of many materials are intimately associated with moisture content and thus the rapid and accurate assessment of moisture is of technical and commercial importance. A notable example occurs in the foundry, where the moisture content of moulding and core sands must be held within fairly narrow limits. When the metal is poured, too much moisture in the sand may generate steam and result in porosity of the casting, while with insufficient moisture there is danger of the mould or core collapsing, either wholly or in part.

The accepted laboratory test for moisture content employs a gravimetric method of assessment. A measured quantity of material is weighed, completely dried out in an oven, and then again weighed. From the two weights obtained the percentage moisture content is calculated. While this method is precise, it is time-consuming and, of course, removed from the workplace or point of application. The "SPEEDY" tester was developed by Thomas Ashworth and Co. Ltd, of Burnley, Lancashire, as a simple, portable, direct-reading instrument that could be used by unskilled workmen. It is not intended to replace the laboratory method but to supplement it by providing the means of rapid and routine checks in the workshop or foundry.

Principle of operation

This instrument is based, in principle, on the reaction between calcium carbide and water. A specially prepared calcium carbide powder composition is supplied with the tester. When a measured quantity of this is brought into contact with the material in a sealed container, acetylene gas is generated. The pressure of this gas is indicated on a pressure gauge calibrated to show the percentage of moisture. A fixed weight of material is subjected to test, of course, and for this purpose a counterpoised balance is provided. A small ladle of precise capacity is used for the measurement of the carbide charge. To ensure constant accuracy, the pressure gauge, which is mounted in the base of the light-alloy mixing flask, is specially built with a beryllium-copper Bourdon tube. Material to be tested is placed in the flask, calcium carbide is measured into the hollow cap, the two elements secured by a hinged, screw clamp, and the contents shaken together. In two to three minutes the percentage of moisture in the material can be read from the dial of the pressure gauge.

All instruments and apparatus are made to a single standard size and are housed in a carrying case measuring 15 in × 12 in × 4½ in, having a total weight of 12 lb. To meet the specific requirements of different industries, five different dial calibrations are available. Although foundry sand rarely exceeds 10 per cent moisture content, the model Type D1, registering from 0 to 20 per cent with increments of 0·2 per cent, has been found most suitable for use in the foundry.

Gauging Rear-Axle Assemblies

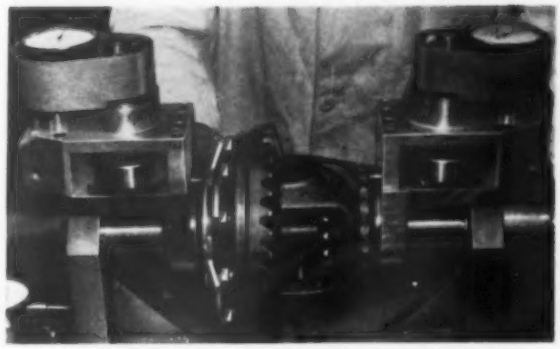
Special Equipment and Procedures Developed to Facilitate the Production of Standard Vanguard and Triumph TR.3 Axle Units

IN the production of the Vanguard and TR.3 range of axles there are two points of assembly where the contingent accumulation of the tolerances on constituent component items calls for the insertion of shims to establish the required operational adjustment. Following is a brief description of how these problems—the determination of shim thickness for the differential bearings and for the outer axle bearings—have been overcome by the provision and use of specially constructed gauging apparatus.

Differential bearings

The first problem is to ascertain the thickness of shims required to provide a predetermined pre-loading of each differential bearing, and also to ensure the correct amount of backlash between the crown wheel and pinion, taking into consideration any variation from standard in the width of the individual bearings. Basically, the principle of the gauge consists of two screwed collars which may be adjusted to take up the width occupied by the bearings and shims when the crown wheel assembly is correctly in mesh with the pinion. Relative movement of these collars from a zeroed dimension is conveyed by push rods and rockers through an angle of 90 deg and displayed on a suitably calibrated dial indicator.

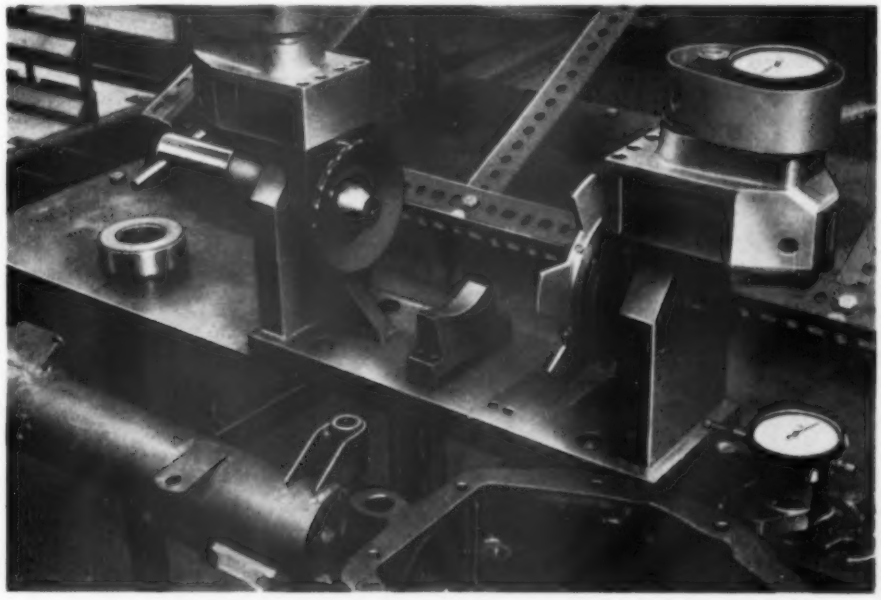
In order to compensate for the slight variations in the width of roller bearing races, each dial indicator is mounted to move in a vertical slide against a spring loading. The position at each gauging operation is determined by the insertion of the specific roller bearing, to be used in the assembly beneath its base. Thus, if the width of the race varies to either side of a nominal limit, the position of the dial indicator is adjusted by the same amount from its zero to compensate. At the beginning of each shift, or at any other convenient interval, each indicator is zeroed on the nominal limit by means of a precision setting ring.



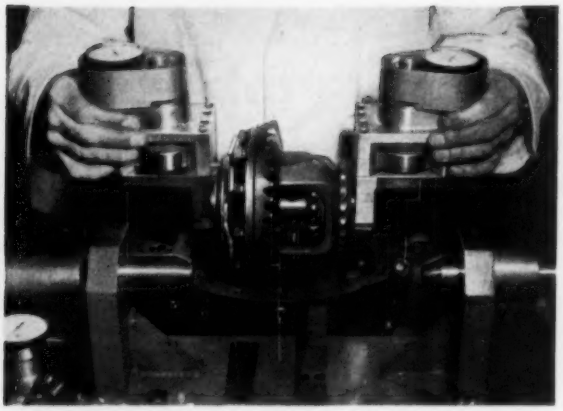
The gauges, with bearings inserted, are slid on to the assembly

Method of gauging

An axle housing, complete with a pinion installed, is brought to the gauging station and is supported on a substantial carrier which is later used for the subsequent assembly operations. The two taper roller bearings to be used are placed beneath the dial indicators on the gauging fixture and are rotated to run the rollers down to their minimum position. An assembled crown wheel unit is



Gauging station and support fixture for differential and crown wheel assembly. The dial gauge on the right has a magnetic base and is used to check crown wheel backlash



Complete with gauges, the assembly is placed in the axle housing

Backlash is checked by a dial indicator mounted on a magnetic base

placed on the gauge stand and the gauges are slid inwardly to pick up the unit. This operation of supporting the crown wheel unit whilst positioning the gauges is undertaken merely as a safeguard against possible damage. The crown wheel assembly complete with the gauges in position is then lifted from the stand and located in the axle housing.

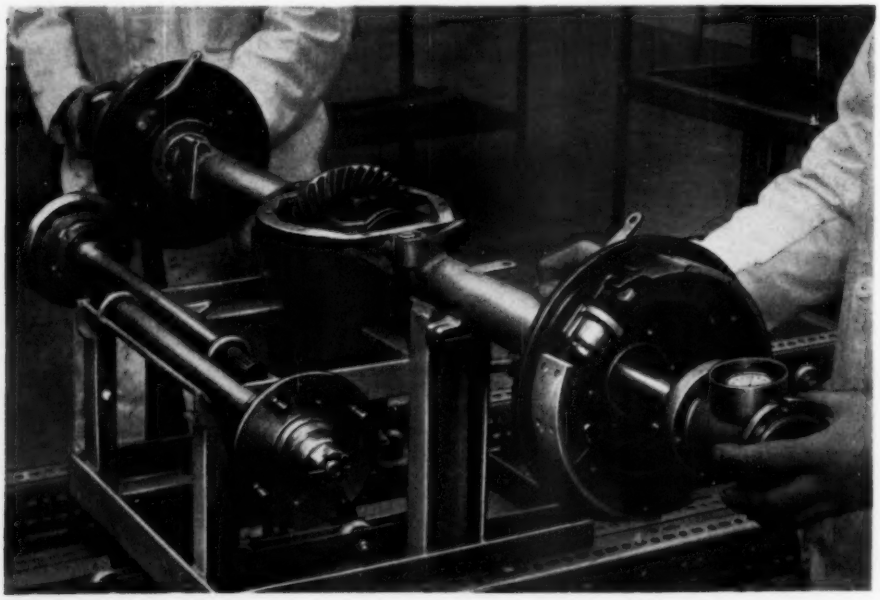
In this position, the internally threaded sleeve on each gauge is screwed outwards; first, to move the crown wheel into mesh with the pinion and, secondly, to take up any end float on the opposite side. Axial movement of the screwed sleeves relative to the bodies of the gauges is transmitted to the dial indicators by the mechanical means already described, and the readings show the thickness of the shims to be fitted beneath each bearing. To the value indicated on a dial is added a predetermined amount to produce the desired pre-load condition in the bearing on assembly.

A third dial indicator, mounted on a specially adapted magnetic base, is then used to verify that the crown wheel has the correct amount of backlash in its engagement with the pinion. After checking this—against a predetermined standard value—the gauge and the crown wheel assembly is removed from the axle housing, and the gauges are withdrawn from the assembly. Shims to the calculated value are fitted to each of the bearing shoulders of the assembly and the bearings are then pressed into position. The crown wheel assembly is then complete and is fitted into the axle housing. Gauging, fitting, and assembly is performed by one man, and the entire operation takes 278 sec to complete.

Axle bearings

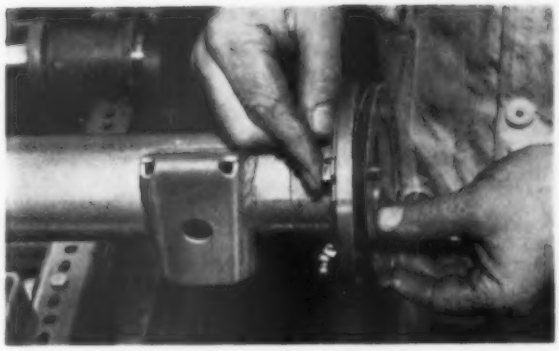
In this case the gauging problem is to determine the thickness of shims required between the brake back plate and the axle-tube flange in order to provide the desired pre-loading of the taper roller bearing in the hub. The measuring faces under consideration are the inner face of the brake back plate, the hub flange face, and the face of the centralizing button located in the crown wheel assembly, against which the end of the axle half-shaft abuts. It is not practical to simplify the problem by utilizing the axle-tube flange as a gauging surface as the thickness of the back plates is not constant.

Two gauges are required, each comprising a long tube, closed by an end stop at one extremity and at the other



Insertion of gauges into the axle tubes. Wedge device is in position on the crown wheel assembly. Half shaft and hubs are on left of carrier

provided with a sliding collar member. At its outer end, the sliding collar is furnished with a flange on which the hub assembly can be located. The axle half-shaft is accommodated inside the long tube until it abuts against the end stop. A gap will then be left between the sliding collar flange and the hub face, and the width of this gap is measured by means of a dial indicator mounted on the sliding collar. Since the brake back plate is already positioned tightly between the inner face of the sliding collar and the axle-tube flange, the specific thickness of that component is already taken into account. The collar member is slid into a relative position on the gauge tube, moving the dial indicator bodily and thus effecting the necessary compensation for any departure from the nominal standard.



Fitting shims to the required value prior to final assembly

Gauging procedure

It is first necessary to position the thrust button located in the crown wheel assembly, to a central position in order to ensure that the differential cross pin is free from contact. This is simply and quickly effected by means of hinged and spring-loaded pairs of taper wedges, as illustrated. The next step is to place two brake back plates in position on the ends of the axle tubes and then to slide the gauges into the tube, making sure that the ends of the gauge tubes abut against the faces of the thrust button. On each gauge the collar is slid inwardly and secured to the axle-tube flange, clamping the brake back plate tightly in position. With the gauge thus positively located, a gauge block having a flat surface is held up to the face of the collar flange to depress the dial indicator plunger to the level of the flange face. The dial of the indicator is then turned to zero to enable a direct reading of the gap width to be made in a subsequent operation.

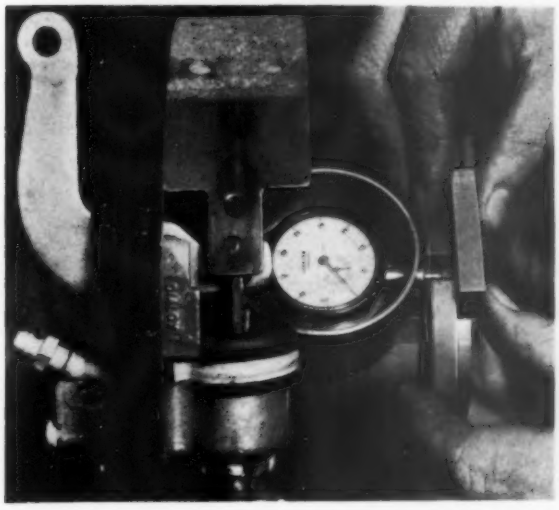
Spring-loaded wedge device for centering thrust button on cross pin before gauging

A half-axle shaft and hub is then inserted into each gauge, making certain that the half-axle shaft end abuts on the solid end stop of the gauge tube. This is of importance since the length of this end stop is identical with the distance between the two flange faces of the sliding collar, thus reproducing the exact conditions of the final assembly. Consequently, the gap which appears between the gauge collar flange and the hub flange will represent the thickness of the shims necessary to eliminate all end float from the assembly. From the dial indicator mounted on the sliding collar the actual measurement of the gap can be read off. To this reading a predetermined figure is added to provide a small amount of pre-load to the bearing.

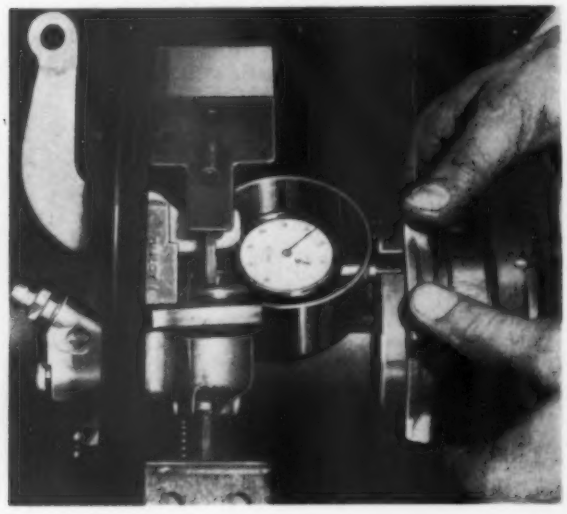
Finally the half shafts, gauges and brake back plates are withdrawn, and shims to the required value fitted on the end of each axle tube. Brake back plates, half shafts and hubs are refitted and the whole assembly is then bolted up to complete.

The operation is carried out by two men, each operating a gauge at opposite ends of the axle, and requires 102 sec.

With the gauge in position the dial indicator is zeroed



Measuring the gap between the gauge and the hub flange



JAGUAR PLATING PLANT

An Aggregate of Two Automatic Plants and a Manually Operated Plant, all of Efco-Udylite Design, for Chromiu

FOR many years the decorative plating of the majority of the body trim parts for Jaguar cars had been contracted out to various firms of trade platers who had to satisfy a rigid specification for a finish of high quality. Only a minor proportion of the smaller component items were plated by hand methods at the Jaguar works. In 1959, faced with rapidly increasing production requirements, coupled with a desire to bring quality of finish under a single, direct control and to reduce plating costs, the Jaguar Company decided to install at the Coventry works, plant and equipment of a capacity to meet its current and foreseeable future needs. The contract for the complete project—design, construction and installation—was awarded to the Electro-Chemical Engineering Co. Ltd, of Sheerwater, Woking. After a comprehensive survey of the range of components to be processed, and the current and potential requirements of each item, it was decided to install three independently operable plants, identified as plants A, B and C.

Plant A, copper plating, automatic

This is a return-type, fully automatic, Efco-Udylite "Junior" machine but is provided with extended tank capacity. It is designed for the deposition of bright copper on a wide range of small polished steel components, including gear levers and other internal steel fittings. The automatic transfer of work from tank to tank is effected by a lifting frame carrying a cathode track from which the plating racks are suspended. Operation of the lifting frame and the pusher-type traversing mechanism is by means of solenoid-controlled hydraulic cylinders. While in the multi-stage tanks, the racks are not lifted but remain immersed when traversing movements occur. The hydraulic unit, with a single electric motor, oil pumps, and reservoir, is grouped with a contactor panel and control gear in a floor-mounted cubicle.

Overall dimensions of the plant are 47 ft long, 6 ft 2 in wide, and 9 ft high. It includes twenty separate processes, the more important being:

No. 1. Alkaline anodic clean; 180-200 deg F; 75 amp/ft^2; 4 min 34 sec

No. 4. Acid dip; 50 per cent by volume hydrochloric acid; 1 min 14 sec; rubber-lined tank

No. 7. Alkaline anodic clean; 180-200 deg F; 75 amp/ft^2; 4 min 34 sec

No. 10. Acid dip; 25 per cent by volume hydrochloric acid; 1 min 14 sec; rubber-lined tank

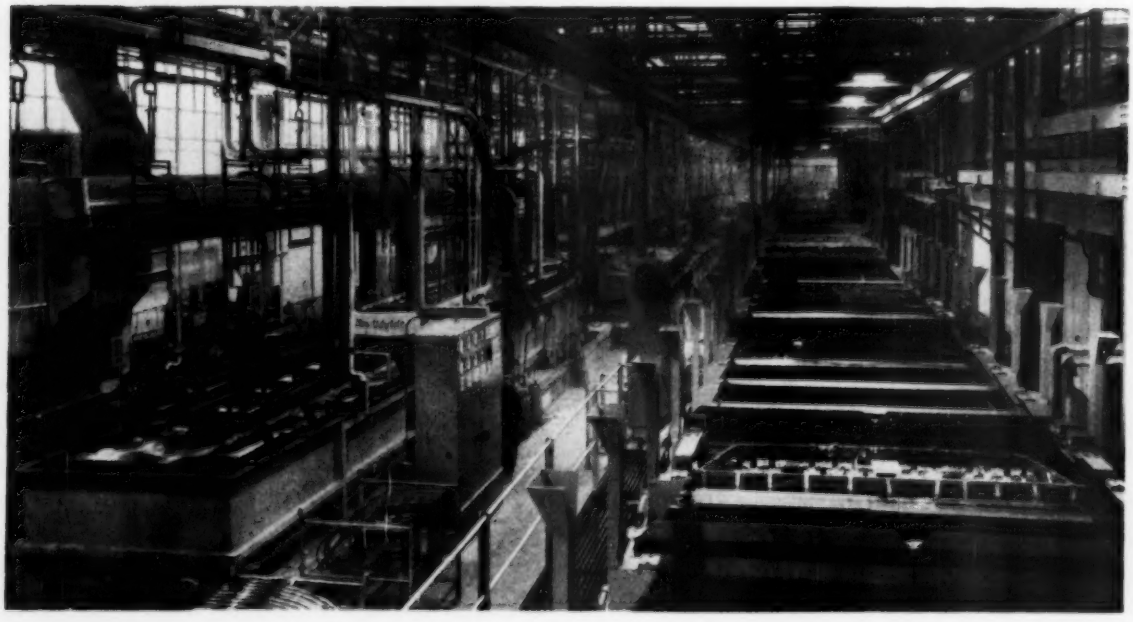
No. 13. Cyanide copper strike; 140 deg F; 40 amp/ft^2; 4 min 34 sec; rubber-lined tank

No. 16. Acid copper plate ("Ubryco" solution); 120 deg F; 40 amp/ft^2; 4 min 34 sec; air agitated; rubber-lined tank; volume 1,933 gal

Other tanks are for air-agitated cold rinses between processes and a final hot rinse at 200 deg F. All air for solution agitation is passed through metal and nylon filters to remove any oil contamination, since the plating shop is in communication with an adjacent press shop. Hot tanks are heated by high-pressure, hot-water coils immersed in the solutions. Fume exhaust from certain tanks—cyanide copper and cleaners — is arranged on the lip-extraction system. Controls are grouped in a console, providing remote control of current density and of all auxiliary equipment.

The work is carried through the process sequence on plating racks measuring 14 in × 24 in deep. These may be

View along the line of manual Plant C, with automatic Plants A and B on the left, in foreground and distance respectively



loaded to a maximum work area of 3·5 ft² and a maximum weight—rack and work—of 25 lb. Throughput is at the rate of 36 racks per hour.

Plant B, nickel and chromium plating, automatic

Of generally similar design to Plant A, this is a return-type, fully automatic, Efco-Udylite "Cyclemaster" machine, with extended capacity. It is arranged for the bright nickel plating and chromium plating of both copper-plated components from Plant A and polished brass components. On this machine the plating racks are 14 in × 36 in deep, have a maximum work area of 3·5 ft², and may be loaded to a maximum inclusive weight of 25 lb. Rate of throughput is 60 racks per hour. Overall, the plant is 70 ft long, 7 ft wide, and 11 ft high, and twenty-five separate processes are incorporated.

The more important of these processes are:

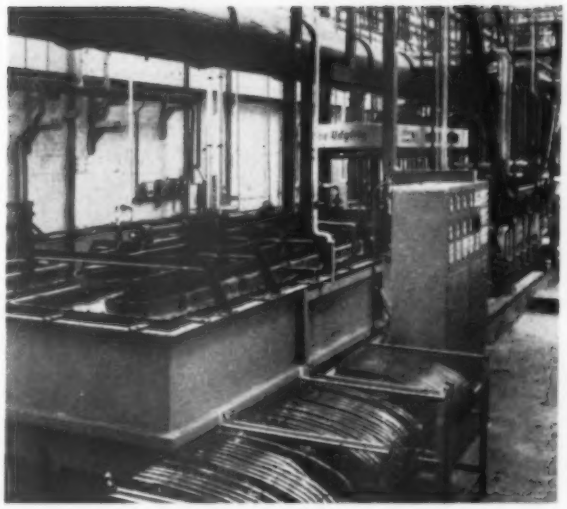
No. 1. Spray alkaline clean; 130-180 deg F; 5 min 30 sec; solution recirculated from reservoir tank below floor of loading bay

No. 3. Cathodic alkaline clean; 180-200 deg F; 50 amp/ft²; 3 min 30 sec

No. 8. Acid dip; 25 per cent by volume hydrochloric acid; 30 sec; rubber-lined tank

No. 11. Cyanide copper flash; 140 deg F; 40 amp/ft²; 1 min 30 sec; rubber-lined tank

No. 14. Bright nickel plate (Efco-Udylite 66 H solution); 140-150 deg F; 60 amp/ft²; 25 min 30 sec; air agitated; rubber-lined tank. A double indexing mechanism allows plating time to be varied in ratio 2:1, with a rack on each traverse stage or on alternate stages. Elsewhere the cycle is unchanged.



Plant A, copper plating on steel components, with control cabinet on left

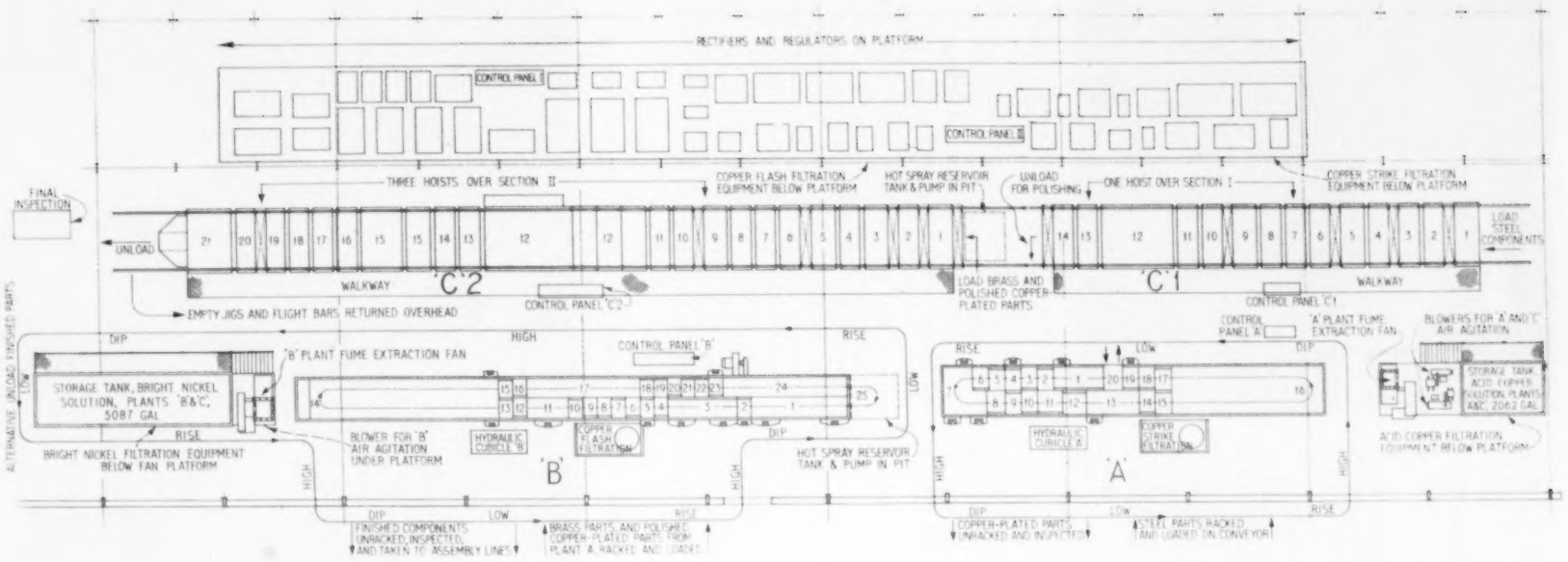
No. 17. Chromium plate (high-temperature, high-ratio solution); 130 deg F; 300 amp/ft²; 6 min 30 sec; lead-lined tank; volume 2,812 gal

Special arrangements have been made to control within close limits the temperature of the solution in the chromium tanks. Heating is by high-pressure, hot water circulated through titanium coils immersed in the solution. A balance is maintained, however, by means of lead cooling coils, and by jackets built externally on the tank, side walls and fed, through thermostatically controlled valves, with cold water.

No fume exhaust system is provided for the chromium process. Instead, the surface of the bath is thinly foam-blanketed with Zeromist, an Efco-Udylite product which reduces the surface tension of the solution. Mist and spray is effectively suppressed and fume extraction equipment is

General view from the opposite end of manual Plant C. On the walkway railing can be seen the immersion timing units

LAYOUT OF PLATING INSTALLATION


RECTIFIERS AND REGULATORS ON PLATFORM
CONTROL PANEL II
CONTROL PANEL I
THREE HOISTS OVER SECTION II
COPPER FLASH FILTRATION EQUIPMENT BELOW PLATFORM
HOT SPRAY RESERVOIR TANK & PUMP IN PIT
UNLOAD FOR POLISHING
ONE HOIST OVER SECTION I
COPPER STRIKE FILTRATION EQUIPMENT BELOW PLATFORM
FINAL INSPECTION
UNLOAD
LOAD STEEL COMPONENTS
WALKWAY
'C'2
'C'1
CONTROL PANEL 'C'2
CONTROL PANEL 'C'1
LOAD BRASS AND POLISHED COPPER-PLATED PARTS
EMPTY JIGS AND FLIGHT BARS RETURNED OVERHEAD
ALTERNATIVE UNLOAD FINISHED PARTS
DIP
HIGH
RISE
LOW
CONTROL PANEL 'B'
'B' PLANT FUME EXTRACTION FAN
CONTROL PANEL 'A'
'A' PLANT FUME EXTRACTION FAN
BLOWERS FOR 'A' AND 'C' AIR AGITATION
STORAGE TANK, BRIGHT NICKEL SOLUTION, PLANTS 'B' & 'C', 5087 GAL
BRIGHT NICKEL FILTRATION EQUIPMENT BELOW FAN PLATFORM
BLOWER FOR 'B' AIR AGITATION UNDER PLATFORM
HYDRAULIC CUBICLE 'B'
COPPER FLASH FILTRATION
HOT SPRAY RESERVOIR TANK & PUMP IN PIT
HYDRAULIC CUBICLE 'A'
COPPER STRIKE FILTRATION
STORAGE TANK ACID COPPER SOLUTION PLANTS 'A' & 'C', 2062 GAL
ACID COPPER FILTRATION EQUIPMENT BELOW PLATFORM
'B'
'A'
FINISHED COMPONENTS UNRACKED, INSPECTED AND TAKEN TO ASSEMBLY LINES
BRASS PARTS AND POLISHED COPPER-PLATED PARTS FROM PLANT 'A' RACKED AND LOADED
COPPER-PLATED PARTS UNRACKED AND INSPECTED
STEEL PARTS RACKED AND LOADED ON CONVEYOR

Plant A, copper plating on steel components

1, anodic clean
2, cold rinse
3, cold rinse
4, acid dip
5, cold rinse
6, cold rinse
7, anodic clean
8, cold rinse
9, cold rinse
10, acid dip
11, cold rinse
12, cold rinse
13, copper strike
14, cold rinse
15, cold rinse
16, acid copper plate
17, cold rinse
18, cold rinse
19, hot rinse
20, load and unload

Plant B, nickel and chromium plating on copper-plated parts and polished brass components

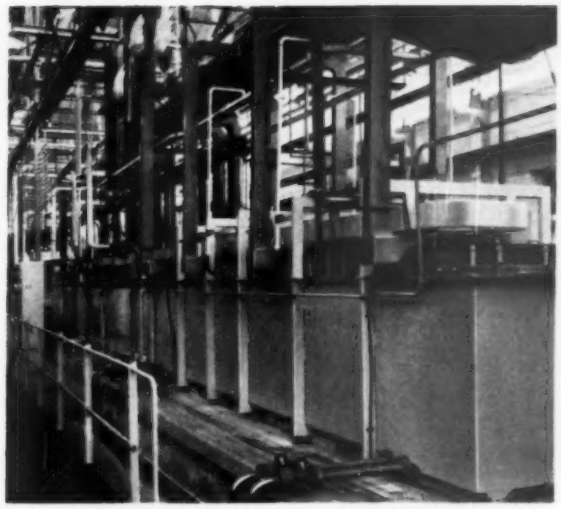
1, spray alkaline clean
2, hot rinse
3, cathodic clean
4, cold rinse
5, anodic clean
6, cold rinse
7, cold rinse
8, acid dip
9, cold rinse
10, cold rinse
11, copper flash
12, cold rinse
13, cold rinse
14, bright nickel plate
15, cold rinse
16, cold rinse
17, chromium plate
18, drag out
19, cold rinse
20, cold rinse
21, neutralize
22, cold rinse
23, hot rinse
24, dryer and air blast
25, load and unload

Plant C, Section 1, copper plating on steel components

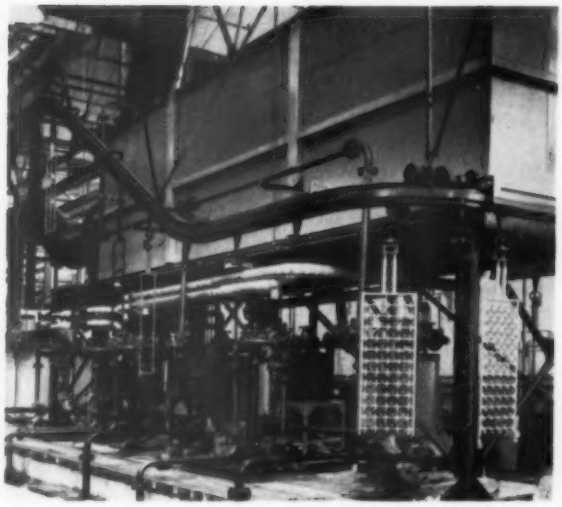
1, anodic clean
2, cold rinse
3, acid dip
4, cold rinse
5, anodic clean
6, cold rinse
7, acid dip
8, cold rinse
9, copper strike
10, cold rinse
11, cold rinse
12, acid copper plate
13, cold rinse
14, hot rinse

Plant C, Section 2, nickel and chromium plating on copper-plated parts and polished brass components

1, spray clean
2, hot rinse
3, cathodic clean
4, cold rinse
5, anodic clean
6, cold rinse
7, acid dip
8, cold rinse
9, copper flash
10, cold rinse
11, cold rinse
12, nickel plate, cells and conventional
13, cold rinse
14, cold rinse
15, chrome, cell and conventional
16, drag out
17, cold rinse
18, neutralize
19, cold rinse
20, hot rinse
21, dryer



Nickel tank of Plant B, with "plating out" tank at the end



Nickel solution storage tank. Below, filtration pumps and filter presses

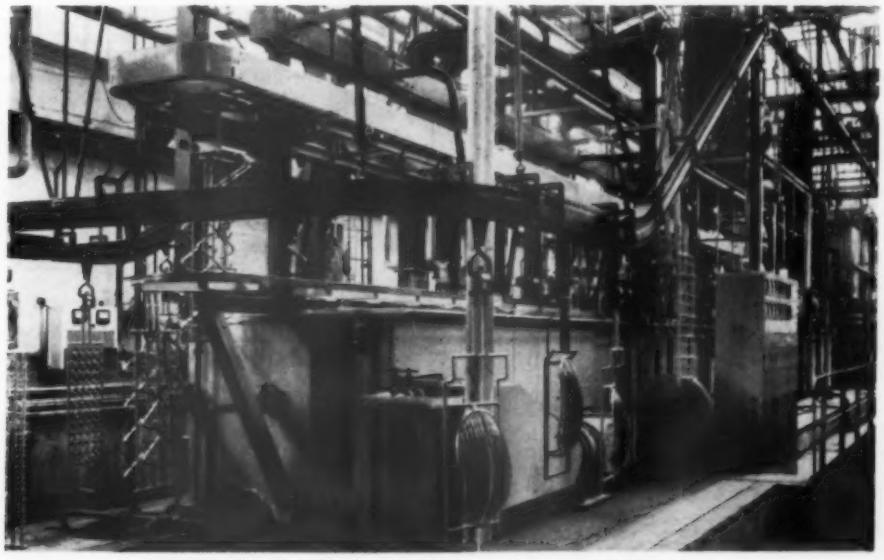
not required; this is an important advantage in reducing consumption of chromic acid. Applied in the correct ratio of concentration and with adequate control of bath temperature, the method is accepted officially as meeting the purpose for which the Regulations—requiring mechanical means of spray or vapour removal from chromium plating workplaces—were established in 1931. Incidental advantages of Zeromist are reduced drag-out and, consequently, less contamination of rinse water.

On the nickel plating tank a fume exhaust system is fitted, all the ducts being made of a rigid PVC material. At the end of the nickel tank, where the plating conveyor makes its return loop, is an electrolytic purification tank. In this, impurities in the solution are "plated out" on to collector plates. The nickel deposited is recoverable and, of course, is of value. Normally, the plates are removed for nickel salvage at intervals of six months.

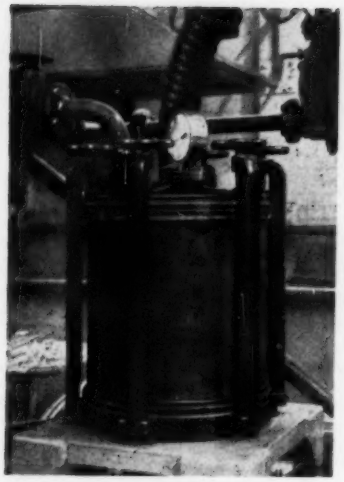
The last sequence stage of the "B" plant is a tunnel-type drying oven. Air is continuously recirculated by a fan through a heating battery to maintain a temperature of 200 deg F, in which the plated and rinsed parts spend 5 min 30 sec. Plants "A" and "B" are designed to handle relatively small parts of steel or brass. Larger components are processed on "C" plant, which is divided into two manually operated, power hoist, plating lines.

Plant C, Section 1, copper plating, manual

This Section of Plant C, corresponding to Plant A previously described, is arranged for copper plating large steel components, particularly bumper bars. The same solutions and the same process sequence are used; the only difference is that single instead of duplicated cold-rinse tanks are employed. A power hoist runs on a track over the line of tanks and an operator on the walkway lifts and traverses the racks of work suspended on flight bars as required. A single-stage tank on this plant is 3 ft 6 in long, 6 ft 10 in wide and 4 ft 9 in deep. The racks are 6 ft 2 in × 3 ft 6 in deep and may be loaded with conventional components up to a work area of 10 ft^2 or with bumper bars or other relatively large components to a maximum of 32 ft^2.



Loading and unloading station of Plant B, nickel and chromium plating of copper-plated steel parts from Plant A and polished brass components



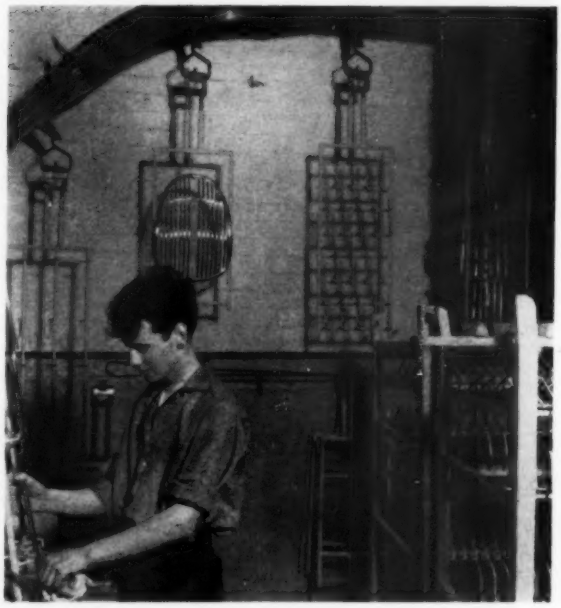
Efco-Hendor filter presses are used for copper and nickel solution purification

Plant C, Section 2, nickel and chromium plating, manual

Copper-plated steel components that have been processed in Section 1 and large components, such as door framings, in polished brass are nickel plated and chromium plated in Section 2. The process sequence and the solutions are the same as those described for Plant B. In this case, however, both the nickel-plating and the chromium-plating stages differ by the addition of single-stage tanks. These tanks—three for nickel and one for chromium—are each arranged as cells and provided with conforming anodes, particularly for bumper bars. An example is illustrated. Over this Section of Plant C, several overhead hoists are provided.

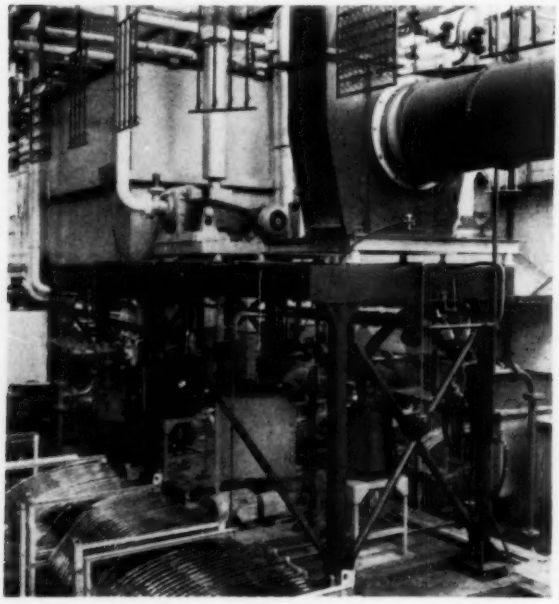
In both the Sections of Plant C the process tanks are each equipped with immersion timing controls. Each timing unit comprises a timer; green, amber, and red signal lamps; a warning bell; and a warning horn. The timer is pre-set to the required process time, and this setting can be locked to prevent interference. When a rack of work is lowered into the tank a limit switch is actuated to start the timer, and while it is operation the green lamp is illuminated. At the end of the predetermined process time the green lamp is extinguished, the amber lamp is illuminated, and the bell rings. Thus the operator is given visual and audible warning that the process is completed. As the rack of work is hoisted from the tank the limit switch is released and the circuit reverts to its original state ready for the next immersion. Should the operator withdraw the rack of work from the tank before the preset time has elapsed and the appropriate signal has been given, the red lamp is illuminated and the warning horn will come into operation. In this manner the operator's attention is called to his error, and the error is also brought to the notice of supervisory staff.

Each of the automatic plants, A and B, is provided with an encircling Fisher and Ludlow "Flowlink" conveyor which, on one side of the plating shop, passes through an aperture in the dividing wall and into the polishing shop and in similar manner returns to the plating plant. In the polishing shop is a series of benches alongside the low-level run of the conveyor on which racks are unloaded and reloaded. Steel parts are racked and loaded on the Plant A conveyor. Copper-plated steel parts from Plant A are polished and then racked for conveyance to Plant B for nickel and chromium plating. Polished brass parts are also loaded on this line in the polishing shop. Finished work from Plant B is unloaded and inspected. On Plant C, steel components are processed in the Section 1 line and unloaded for polishing. At the same station polished, copper-plated components and polished brass components are started on the Section 2 nickel and chromium line. Inspection of these components is in an open area at the end of the line.



A bay in the racking area located in the polishing shop

Copper solution storage tank, with mixing and filtration equipment below



Auxiliary equipment

At the start of Plant A and the end of Plant B are structures which support solution storage tanks, while under the tanks and within the confines of the structures, are the mixing tanks and filtration circuits for the solutions. The storage tank at the end of Plant A is for the acid copper solution used in Plant A and also in Section 1 of Plant C.

The capacity of this tank is 2,062 gal. Mounted alongside the tank is the fume exhaust fan for Plant A and the Roots-type air blowers to provide a supply of filtered air, which is piped to those processes in Plants A and C that require air agitation.

Similarly, the storage tank located at the end of Plant B, is for the nickel solution used in Plant B and Section 2 of Plant C, and has a capacity of 5,087 gal. Alongside this tank is mounted the fume extraction equipment and the air agitation blower for Plant B.

Filtration equipment

The filtration equipment comprises circulating pumps and Efco-Hendor filter presses. For the acid copper and nickel plating solutions Mk VII presses are used, each having a capacity of 3,500 gal/hr. These filter presses and their associated pumps, which are of the La Bour centrifugal type, are housed under the storage tanks, on a floor of acid-resisting tiles. Alkaline copper-strike solution is continuously filtered in Hendor Mk III filters, each of a capacity of 440 gal/hr.

Both the copper- and the nickel-plating tanks are fitted with diaphragms such that the anode and cathode compartments are separated. The solution is pumped from one compartment, through the filters and returned to the same compartment. Diaphragms are of Terylene and ensure a particle-free compartment in which the articles are plated, and obviate the need for anode bags. Also in the filtration circuit are situated the carbon heat exchangers, through which the solution is pumped continuously.

Rectifiers

All the rectifiers supplying the low-voltage direct current for the electrolytic processes are arranged along the length of a balcony, adjacent to the plating shop. They are controlled by stepless regulating transformers, also mounted on the balcony. The main electrical supply from the sub-station, is fed by armoured cable to two main switch and contactor cubicles. These cubicles, which are dustproof, compartmented enclosures, contain the main switchgear for each rectifier, together with protective equipment and remotely operated contactors. The supply is taken from the cubicles to the regulators, thence to step-down transformers and the rectifiers. These are all of the selenium type, the smaller sets being oil-immersed while the larger sets are of the directly water-cooled "Wesculite" type manufactured by the Westinghouse Brake and Signal Co. Ltd. The installed rectifier capacity totals 62,500 amps, and this current is taken to the process tanks by an installation of ten tons of aluminium busbar and five tons of copper busbar.

A cell tank fitted with conforming anode bars arranged for plating bumper bars, Plant C

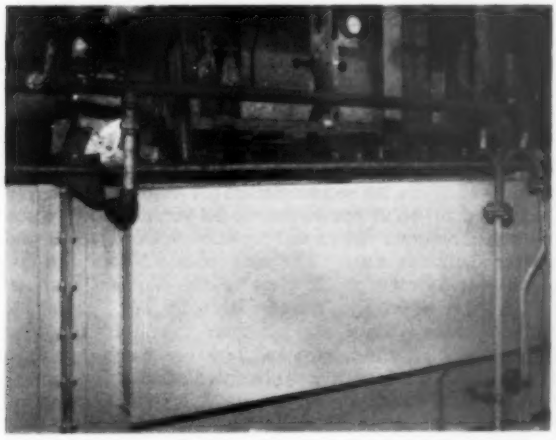
Electrical control and instrumentation

Each plant is complete with its own multi-motor control cubicle, which also houses the controls and instrumentation for the rectifiers. Each rectifier can be switched on and off from these cubicles by the operation of push buttons, and similarly the rectifier outputs can be regulated. The cubicles are on the shop floor, located for convenient operation adjacent to the appropriate plant. Measurement of currents above 5,000 amps is made by the use of transductors, mounted on the d.c. bars, while shunts are used for other measurements.

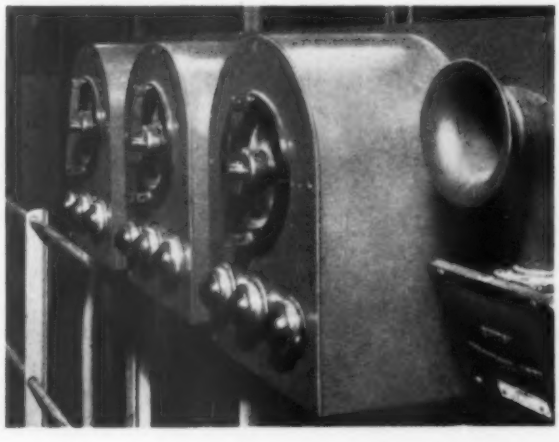
Temperature control

All solutions are automatically temperature regulated by thermostats and motorized valves. The motorized valves are situated in the high-pressure, hot-water lines, adjacent to the heat exchangers or heating coils. Because of the closer control required in the chromium-plating tanks, and in order to remove the heat generated in the electrolytic process, cooling coils are also immersed in the chromium plating solution and, in the case of Plant B, a water jacket is also fitted to the tank. The water flow in these coils and jacket is also thermostatically controlled, using motorized valves.

Thermostatically controlled water jacket on chromium tank of Plant B

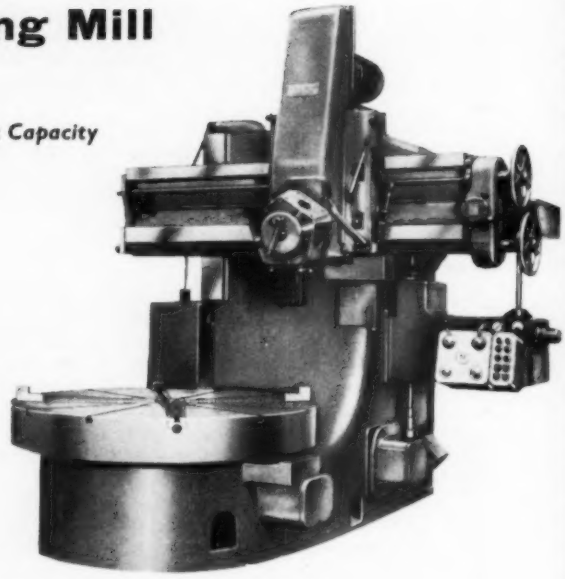


Bank of three timing units for process tanks in Plant C



Vertical Boring and Turning Mill

Elevating Cross Slide Substantially Increases Swing and Height Capacity



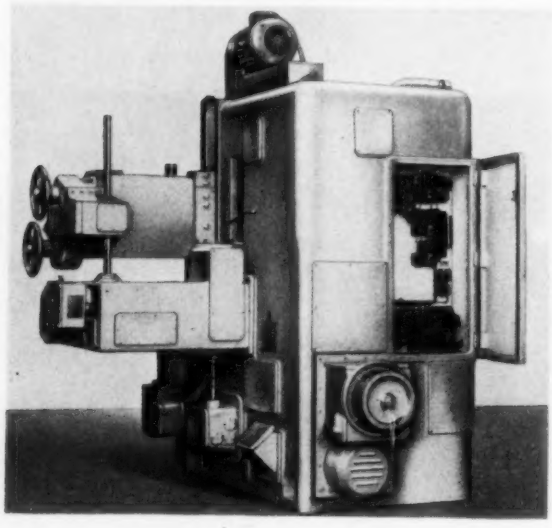
The type EH mill is designed to use the range of attachments available for use with the type DH model

WEBSTER AND BENNETT LTD, of Coventry, have recently introduced a new, single-column, boring and turning mill Type EH, which embodies an elevating cross slide. This represents a marked departure from the conventional mill having a fixed cross slide. On the new machine the cross slide, on which the turret assembly moves horizontally, is itself arranged to move on vertical bearing slides. Thus, the scope of an already quite versatile machine is considerably extended, and its usefulness in die shops, maintenance workshops and to heavy vehicle manufacturers, is thereby enhanced. This new machine is a development of the established DH model, which is of the conventional fixed cross slide form of construction, and special care has been taken during design to ensure that all attachments available in conjunction with the earlier model can also be used on the new machine. These attachments include devices for taper generating, screw cutting, built-in electronic profiling, and an interchangeable ram slide.

There is a separate motor for elevation of the cross slide, and limit switches are provided for safety in operation. The bearing slides are supported by retainers and guideways integral with the main frame of the machine, and the adjustment is effected by a taper gib arrangement. Provision is made for a swivelling movement for the turret slide, and for this purpose gearing to afford accurate adjustment is employed. An optional extra is a power-rotated turret having push-button controls mounted on a panel adjacent to the control panel of the machine.

All the machine controls—for speeds, feeds, rapid power traverse and cross slide elevation — are mounted on one panel, and there is a choice of 12 speeds and feeds, which are selected by means of a hydraulic change system used in conjunction with direct-reading dials. Provision is made for the fitting of automatic starter equipment for all the electric motors, with the control push-buttons mounted on a separate panel adjacent to that for the machine controls. All the electric control equipment is housed in a cavity fitted with a metal door, in the rear of the main frame; this can be seen in the illustration.

Rear view of the machine. Electrical control equipment is housed in a cavity in the main frame



A range of three machines is produced. With the smallest of these, there is a choice of four speed ranges and, with the larger ones, five. Chuck diameters in inches are used in the designation of the machine sizes: these are EH 36, EH 48 and EH 72 respectively, but the corresponding work diameters that can be accommodated are 46 in, 58 in and 84 in. The drive of the four-jaw chuck is effected by a ring gear and pinion. For the smallest machine, the maximum height under the cross slide is 40 in and for the two larger ones it is 48 in; the minimum heights are 19 in and 24 in respectively. The total height of the space required for the accommodation of the three machines, in ascending order of size, is 132 in, 156 in and 160 in, and floor areas necessary respectively are quoted by the manufacturers as being 80 in × 118 in, 100 in × 132 in and 120 in × 152 in.

Welding Mild Steel

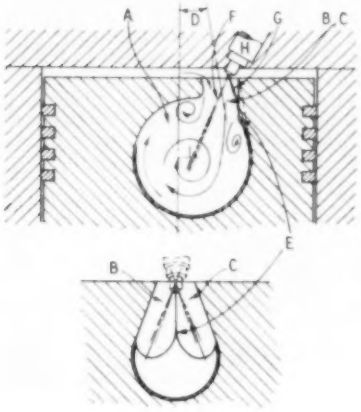
BRITISH Standard B.S.693:1960, has recently been published. It is a revised version of the 1940 edition and is considered to be of application to all forms of structures other than pressure vessels and pressure pipelines, for which special standards exist. The new standard sets out the requirements for the oxy-acetylene welding of general purpose mild steel having a tensile strength not exceeding 33 tons/in² and containing not more than 0·25 per cent carbon, 0·060 per cent sulphur and 0·060 per cent phosphorus. Copies can be obtained from the British Standards Institution, Sales Branch, 2 Park Street, London W.1; its price is 6s and postage will of course be charged extra to non-subscribers.

CURRENT PATENTS

SELECTED ABSTRACTS OF RECENTLY ISSUED SPECIFICATIONS

Compression ignition engine

THIS patent deals mainly with the shape and disposition of a combustion chamber in a compression ignition engine, and with the distribution of fuel over the surface of this chamber. The combustion chamber A is situated in the head of the piston, and is in the form of a hollow sphere whose centre is offset from the



No. 856289

piston axis. Between the chamber and the compression space above the piston is a throat consisting of two overlapping bores B and C; the larger illustration shows that the common plane of their axes is approximately tangential to the chamber, and at an angle D to the axis of the piston; the smaller illustration, which is a sectional view through the common plane, shows that the axes converge at the level of the top face of the piston.

At the intersection of the throat and the chamber there is a natural protuberance E. During operation, two jets G of fuel from the injector H impinge on the walls of bores B and C in such a way that fuel flows rapidly down into the combustion chamber in a continuous film. The upward movement of the piston and the eccentric disposition of the chamber give rise to the entry of turbulent air into the chamber. Some of this air takes up the fuel adhering to the protuberance E, and turbulence further promotes the mixture of fuel and air, but in case the resultant compression ignition is not sufficiently complete there is a further jet F, termed an ignition jet, from the injector.

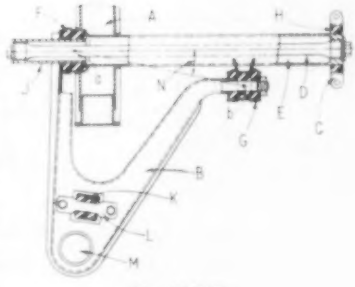
A feature of the angle D between the piston axis and the plane of the throat axes is that it is so slight as to have no appreciable effect on the impingement characteristics of the fuel jets against the throat wall, regardless of the fact that the vertical position of the piston varies slightly according to the timing of the injection. This means that the varying of injection times, to suit different fuels, can be effected in the engine without loss of combustion efficiency. Additionally, the degree of turbulence promoted in the combustion chamber obviates the need for special features such as the masked valves of conventional compression ignition engines. *Patent No.* 856289. *Maschinenfabrik Augsburg-Nurnburg A.G.* (*Germany*).

Wheel suspension

IT is held that a conventional wheel suspension system embodying wishbones and a torsion bar tends to be bulky and heavy and that the bearings have to be manufactured to needlessly fine limits. The specification puts forward a design that does not have these defects to such an extent as earlier systems and also, incidentally, reduces the cost of manufacture. In the illustration is shown the lower of a pair of wishbones B, which can be of sheet metal construction, and a torsion bar spring D arranged longitudinally in the vehicle chassis.

The forward end of the torsion bar is carried in a sleeve J, which is an integral part of the wishbone, and the rear end is fixed in the end of a protective tubular member E. At the rear, the tubular member is supported by a rubber insert H and a bracket C bolted to the vehicle chassis; at the front, it is supported by a cross-member A which, in turn, can be connected to the chassis by rubber mounts or buffers. A pre-stressed rubber bush F is interposed between the cup-shape forward end of the tubular member E and the sleeve J in the leading arm of the wishbone.

The rearmost arm of the wishbone terminates at a pin, which is carried in another rubber bush G, the mounting for which is attached to the tubular member E. At the apex of the wishbone is a hole M for the hub mounting pin, and inboard of this is a shackle L and a rubber bush K, which form the detachable lower mounting of a telescopic damper. The angle N between the inboard pivot axis and the torsion rod axis is approximately



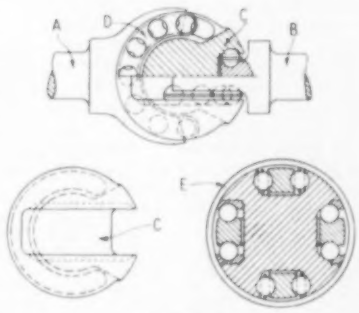
No. 854557

12 deg, and the distance between pivot points *a* and *b* is substantially the same as the distance from the inboard pivot axis to the centre of hole M. *Patent No.* 854557. *Ferdinand Porsche* (*Germany*).

A constant-velocity universal joint suitable for large working angles

THIS joint is made up of three main parts: two identical shafts A and B with forked ends, and a spherical core C; the flanks of each fork, over their whole lengths, register in a groove around the core. Both grooves are, of course, in planes mutually at right angles; they do not completely surround the core but, instead, are of C shape and therefore do not intersect. Ball races are formed in the sides of the grooves and in the corresponding flanks of the forks, and the developed lengths of these races and those of the cages D are such that there is one ball clear of the prong of each fork when the shafts are in line; this ball does not transmit any load until the angular deflection is 15 deg, so full torque can still be transmitted at greater angles of deflection. Angular deflections of as much as 40 deg are acceptable in both planes.

The ball races are designed in the manner of high-shouldered bearings, to



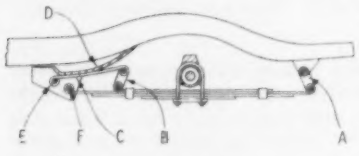
No. 856063

allow for axial thrust, and provision is made in the specification for an alternative scheme in which separate part-circular races are fitted in widened grooves in the core, and for a further alternative scheme involving similar half-races. In the lower right illustration, which is a composite, are seen sectional views of all three types of ball race. Also shown sectionally in this view is a protective sleeve E incorporated in an alternative design of core whose outline is cylindrical. Corrugated rubber shrouds are fitted, in this last design, between the ends of the protective sleeve and the widened flanges of the shafts A and B, for the purpose of dust protection. *Patent No.* 856063. *Gellenkwellenbau G.m.b.H.* (*Germany*).

Leaf spring with modified rate characteristics

IN the illustration is shown the suspension system for the rear wheel of a road vehicle. A leaf spring has a conventional shackle A, at the rear, to link it to the frame. Between the axle mounting and the front eye F of the spring there is a third eye, formed in the topmost leaf of the spring.

Another shackle B connects this eye to the rear of an auxiliary spring C, which



No. 855805

consists of one leaf whose front eye is attached to the spring mounting bracket at point E, above and slightly forward of point F. An abutment D is fixed to the underside of the chassis frame, its dimensions being such as to cause it to bear lightly on spring C under conditions of low static load. The curvature of the abutment is designed so that progressive increases of spring deflection causes proportionately varying lengths of the spring to contact it.

Upward movements of the axle, therefore, have the effect of reducing the unsupported length of spring C, and provide an increasing resistance to further deflection of the main spring. The stated aim of this design is the provision of a comfortable ride over uneven roads. An advantage claimed is that when the weight is removed from the road wheel, as in a jacking operation, the spring C rests on the front eye F of the main spring, so that downward deflection is limited and a reduction in the amount by which the axle hangs is effected.

A further advantage of this last feature is that it can be utilized, either as shown in the illustration or with other stops replacing F, to increase rebound stiffness of the spring over part of its travel. A point made in the specification is that although a semi-elliptic spring is illustrated and described throughout, the modifications are equally applicable to quarter-elliptic springs. *Patent No.* 855805. *Standard Motor Co.*

Fan with rubber insulated blades

AMONG the many noises liable to displease occupants of cars is that emitted by the fan of the engine cooling system. The patent covers the design of an axial flow fan that has been found to have an appreciably lower noise level than that usually experienced with the normal pressed steel or fabricated type. Rubber is used in this design to minimize the transmission of noise and vibration.

Each of the blades A is manufactured separately and, when positioned in the fan, is clamped at its root between the two components B and C that form the hub. The root of each blade is dovetailed in section, and the two faces of the hub components that register with the flanks of these roots are tapered so that the blades are restrained from radially outward movement. Interposed between the flanks and the conical faces, however, is the sheet rubber E that acts as an insulator of noise and vibration.

A ring of equally spaced bolts holds the two components of the hub together, and provides the clamping force that helps to retain the blades. One bolt passes through a hole in the root of each blade, and a rubber bush D is interposed between the bolt shank and the hole. The radial mating faces of adjacent roots of the blades are shaped so that the components afford positive support to each other. *Patent No.* 854690. *Serck Radiators Ltd.*

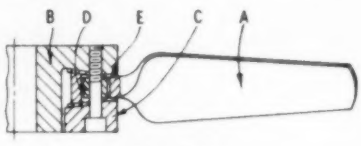
Vehicle springing

A SYSTEM is put forward wherein the suspension medium for a vehicle consists principally of only one spring, preferably a hydro-pneumatic one, and incorporates resilient hydro-mechanical couplings to cause opposite wheels to rise and fall together. To each wheel hub is attached a piston and cylinder arrangement, by means of which vertical displacements of the wheel are transmitted hydraulically to a hydro-pneumatic spring T containing an air chamber S. Diagonally opposed wheels A and D are served by pipe lines E and H; these lines pass through two gear-type hydraulic motor-pumps L and M interconnected by a torsion rod O. Similarly, wheels B and C are served by pipes F and G, torsion rod N and motor-pumps J and K. The hydraulic pipes P and Q connect respectively motor-pumps L and J, and M and K; P and Q are themselves interconnected by a pipe that runs by way of R to the spring T.

Five types of suspension behaviour will now be considered:

(a) *All wheels deflect together.* Hydraulic pressure rises uniformly in pipes E, F, G and H, and in P, Q and R; the spring T is loaded. Motor-pumps J, K, L and M are not affected, so torsion bars N and O do not move. Springing is thus entirely by spring T, which can be made as soft as desired.

(b) *Crossing a transverse ridge.* Two front wheels C and D rise, and in so doing increase the pressure in G and H; motor-pumps J and L, operating as motors, are set in motion in opposite directions, and the pressures in P, Q and R rise. Simul-



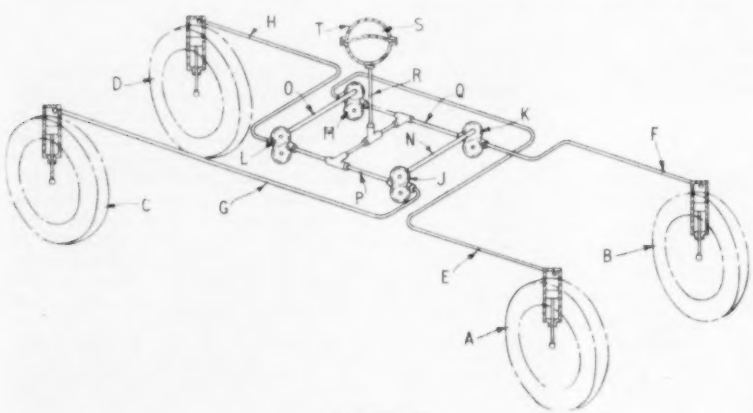
No. 854690

taneously, the movement in motor-pumps J and L is transmitted through torsion rods O and N to M and K, making them run as pumps. All three springing media N, O and T are thus in operation, and soft springing is experienced.

(c) *Pitching during braking or acceleration.* During braking, for example, pressure in G and H rises by a certain amount, and in E and F falls by the same amount. Motor-pumps J and L experience opposed oil delivery, while motor-pumps K and M experience opposed oil suction; there is, therefore, no pressure increase in P, Q and R. However, the torsion rods N and O are subjected to twisting, and the degree of pitching will be controlled by the amount by which they twist: stiff torsion bars reduce pitching, and since this stiffness has no effect in the condition (a) and relatively little in (b), its incorporation is a satisfactory compromise.

(d) *Rolling on bends.* When a left hand bend is taken, for example, pressure rises in F and H, and falls by a similar amount in E and G. The pairs of motors J, K and L, M again behave in such a way that the torsion bars twist but there is no pressure rise in P, Q and R. Rolling is, therefore, controlled by the stiffness of the torsion bars.

(e) *Diagonally opposed wheels deflecting.* If wheels B and C rise, and wheels A and D fall, the hydraulic fluid moves freely through G, P, H and E, Q, F, with no change in pressure in P, Q and R, and with no twisting of the torsion rods. Therefore, only the small forces that arise from inertia of the hydraulic fluid are transmitted to the vehicle. *Patent No.* 855257. *Daimler-Benz A.G.* (*Germany*).



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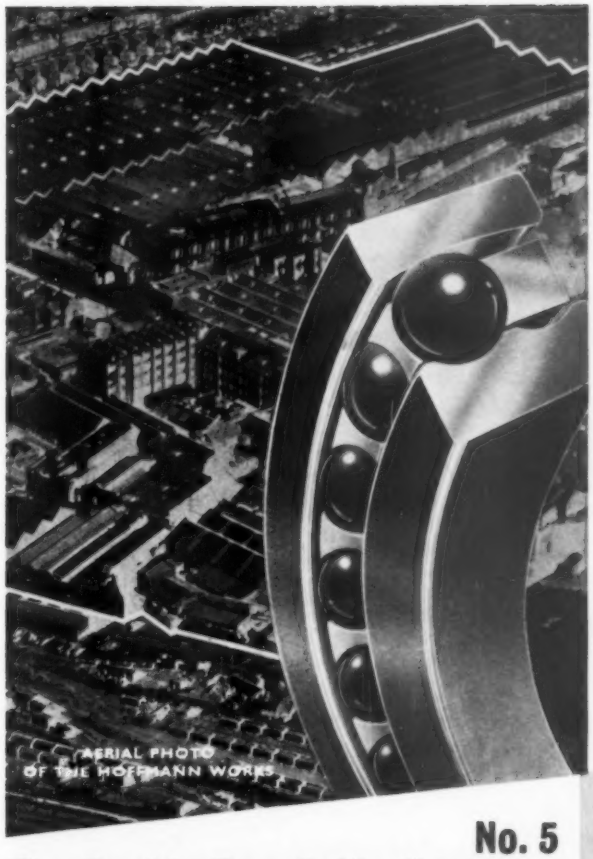

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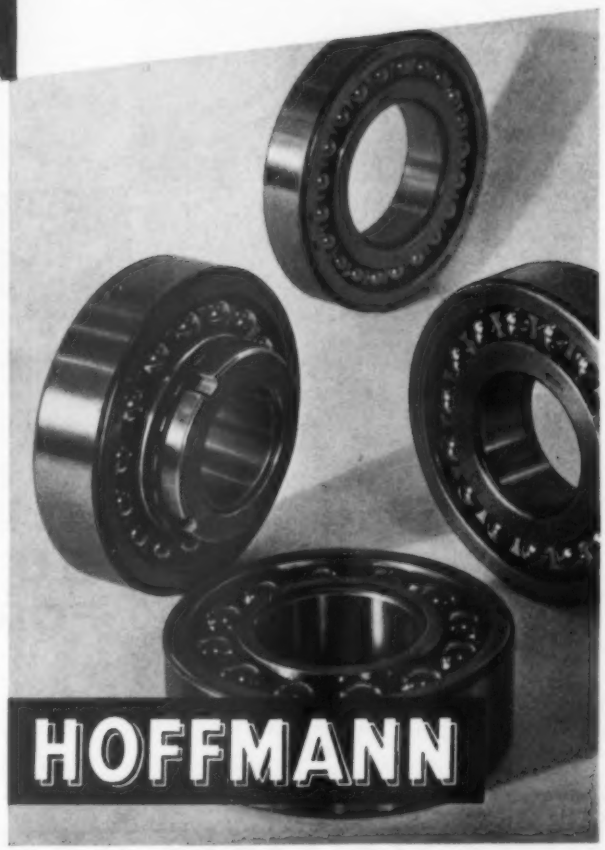

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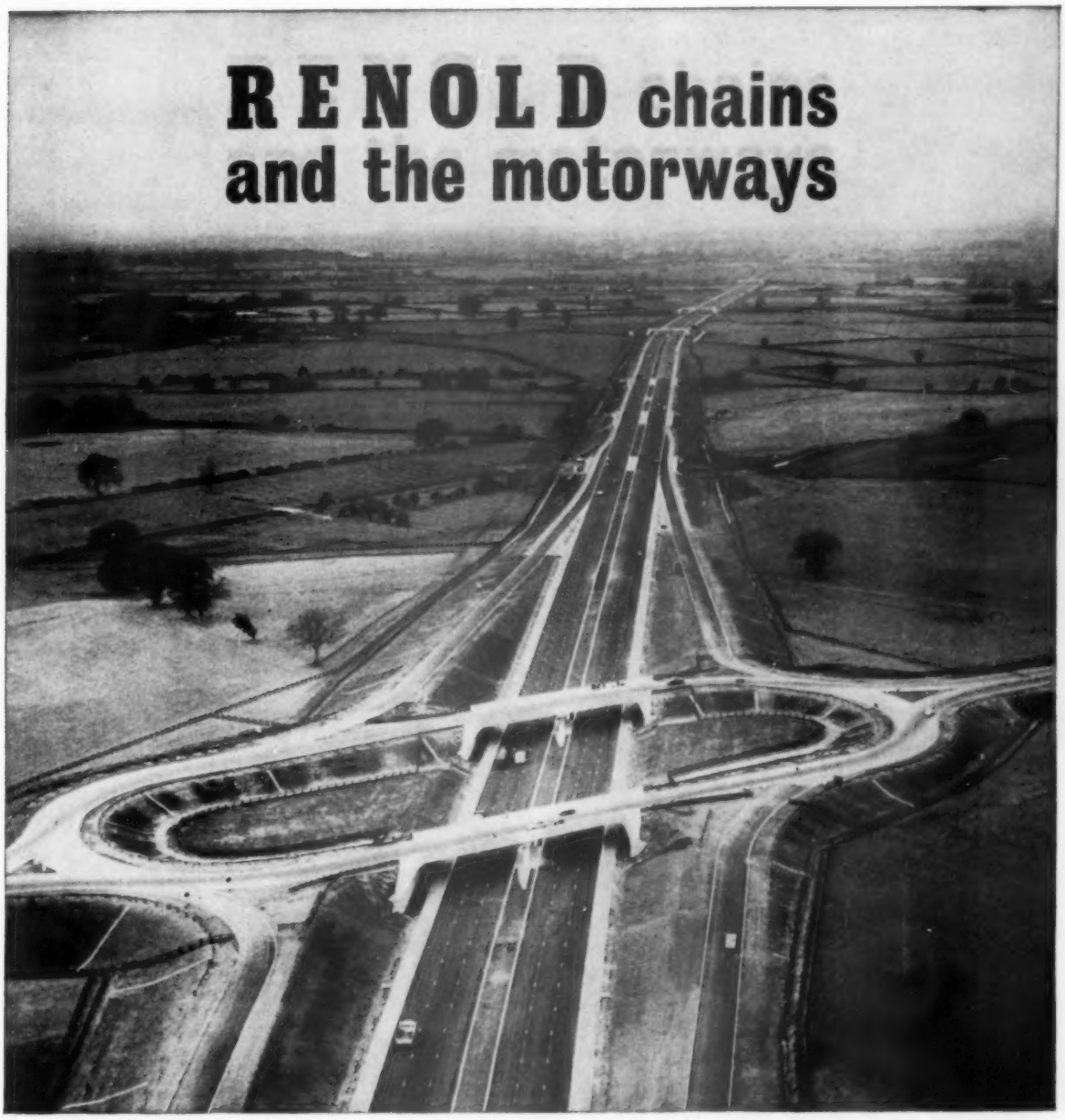

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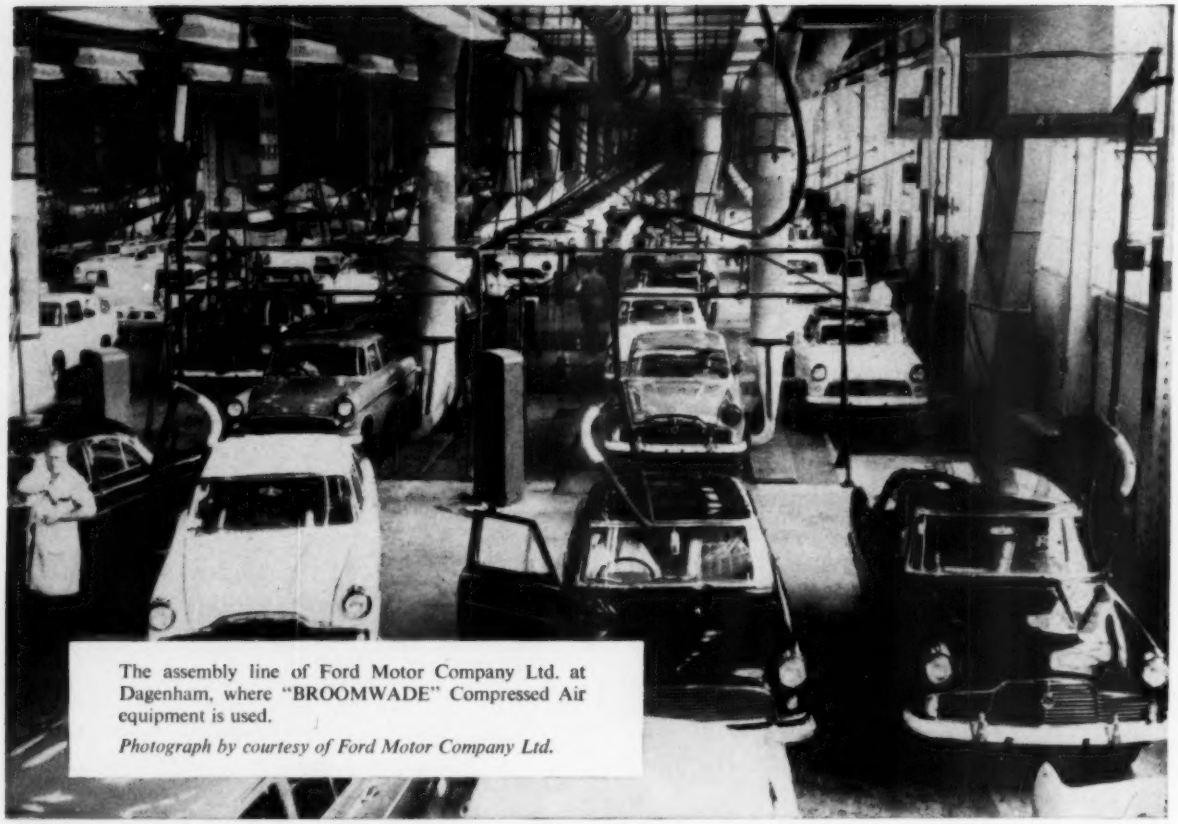

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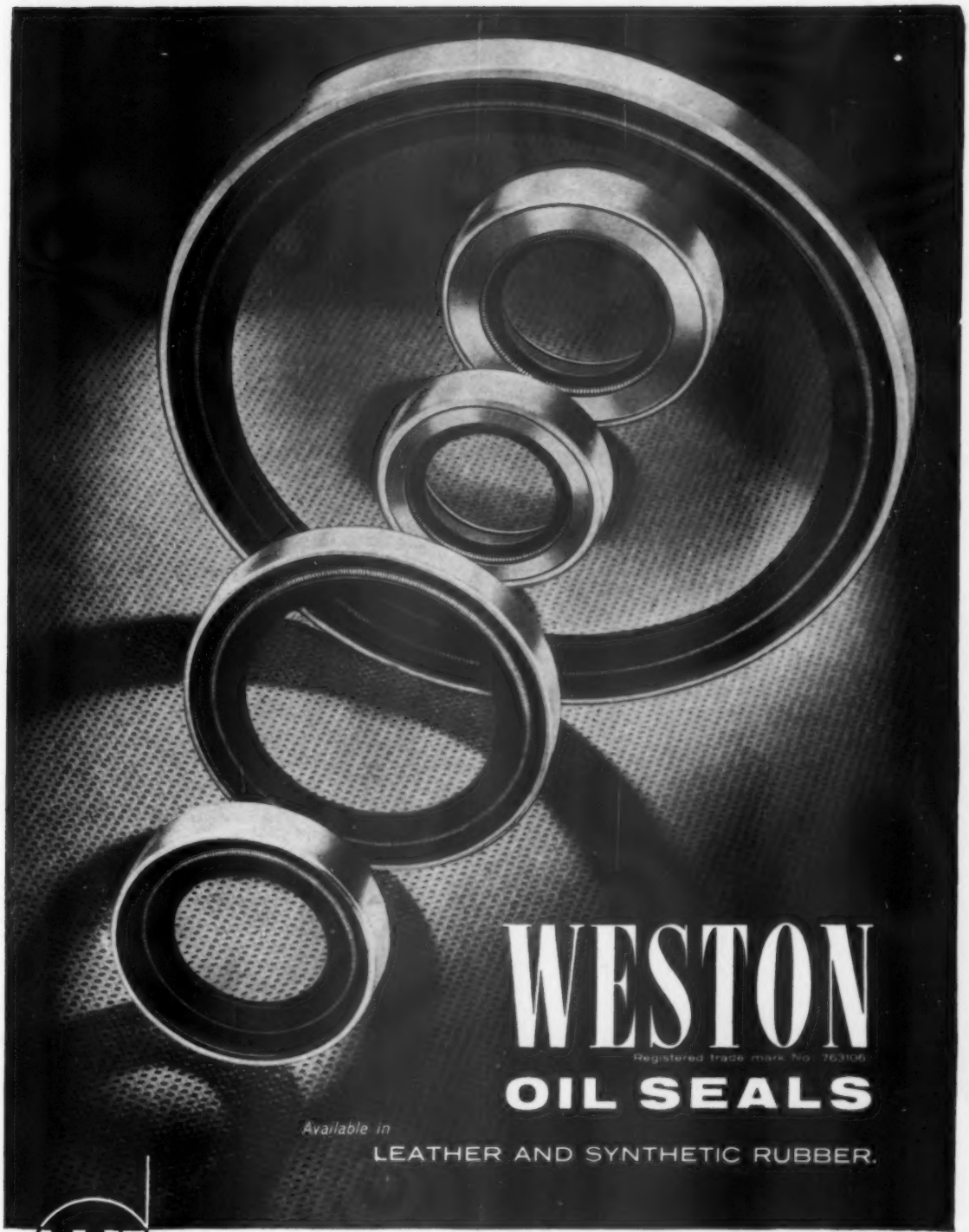

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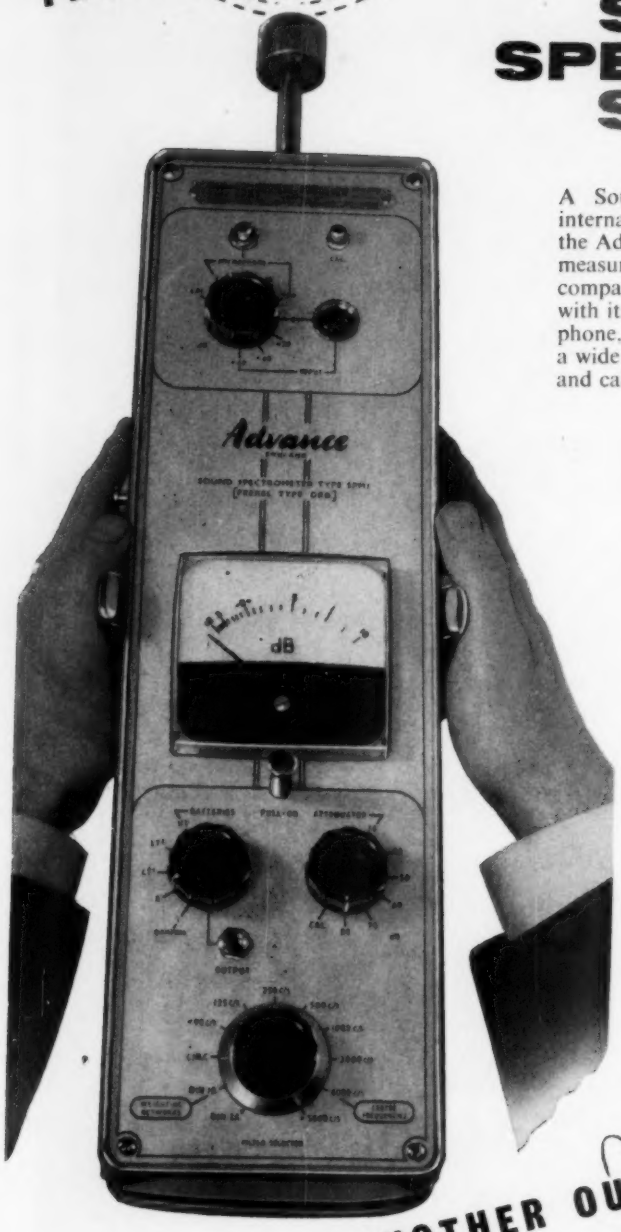

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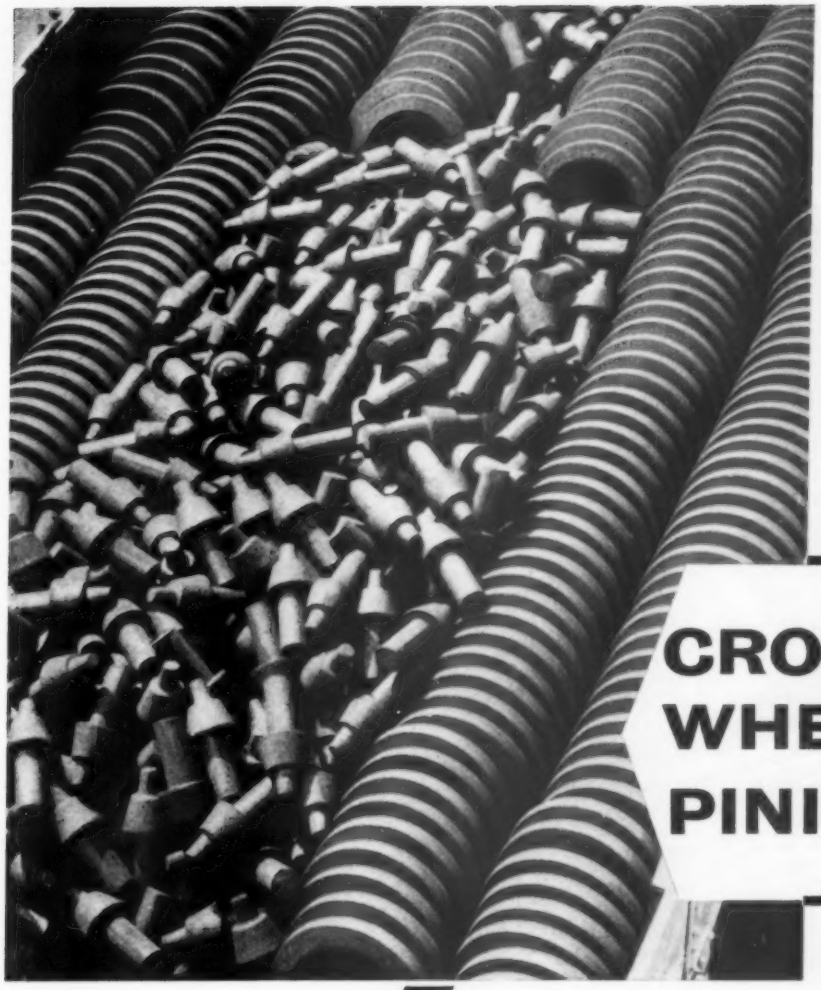

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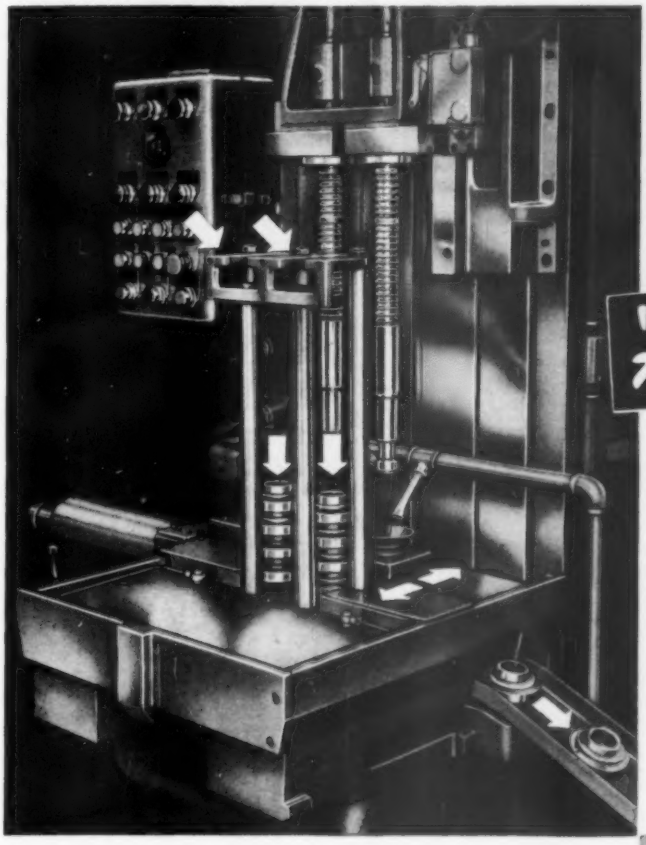

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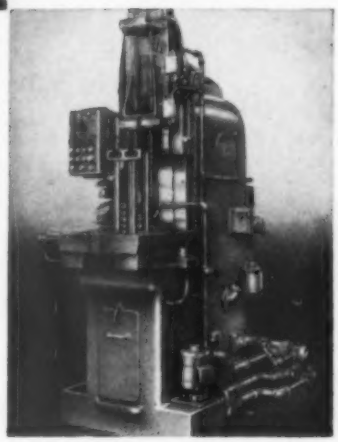

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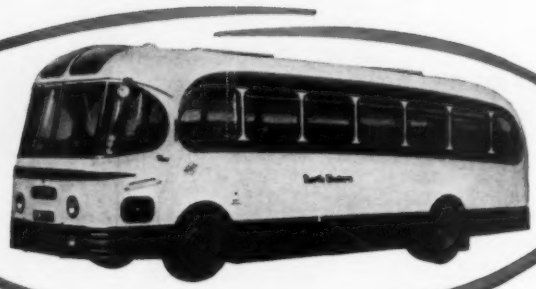

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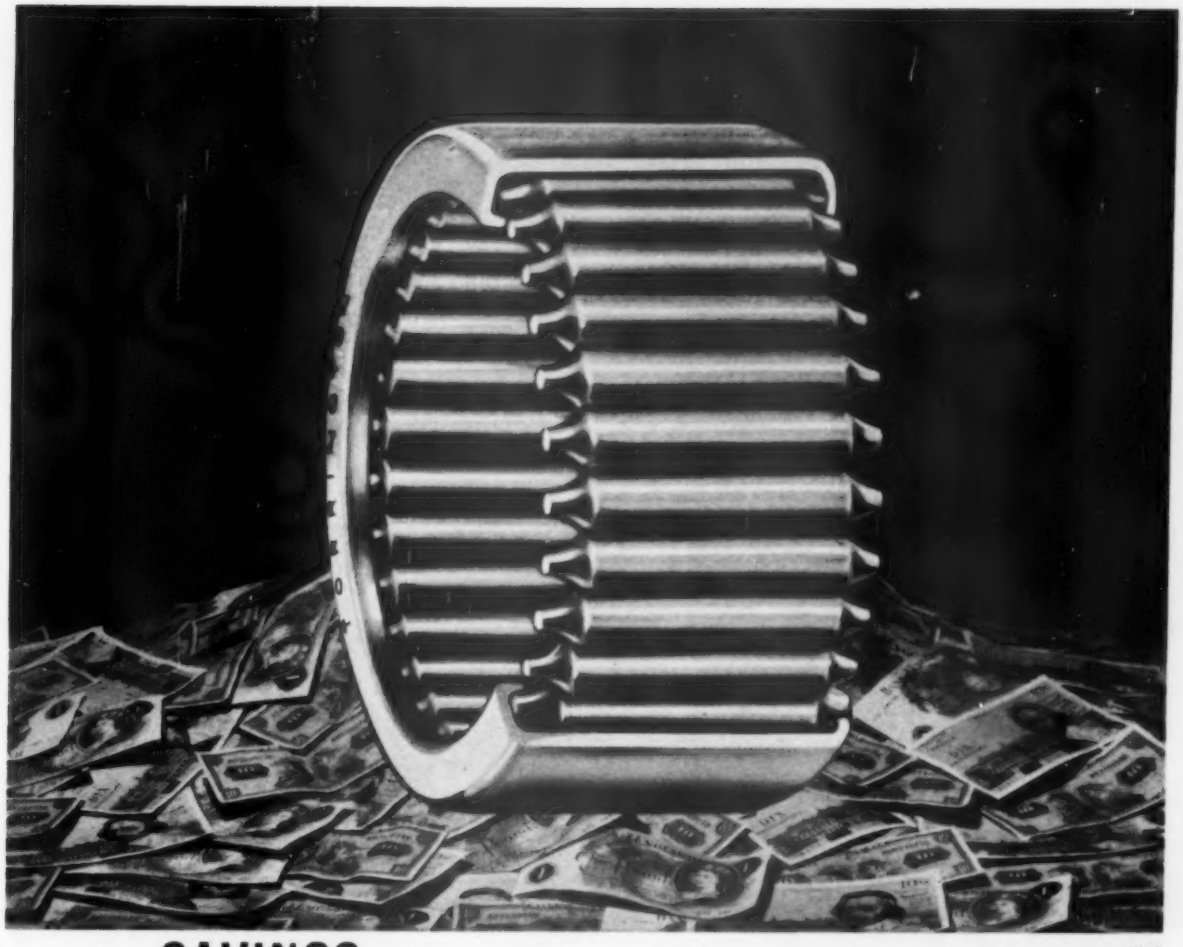

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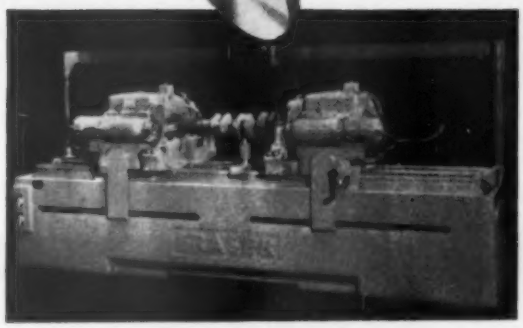

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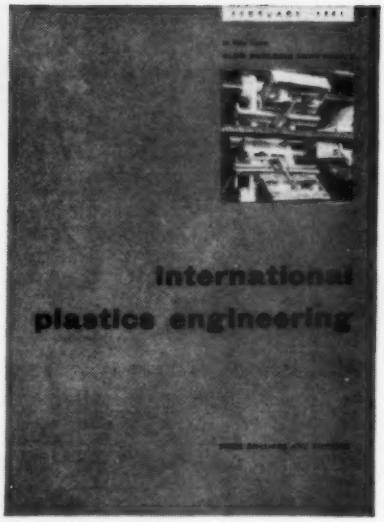

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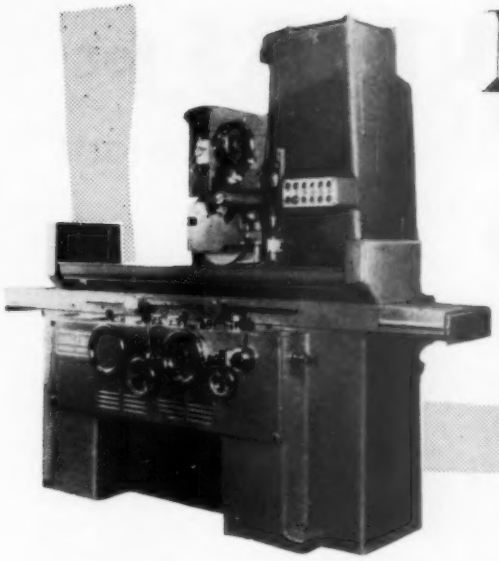

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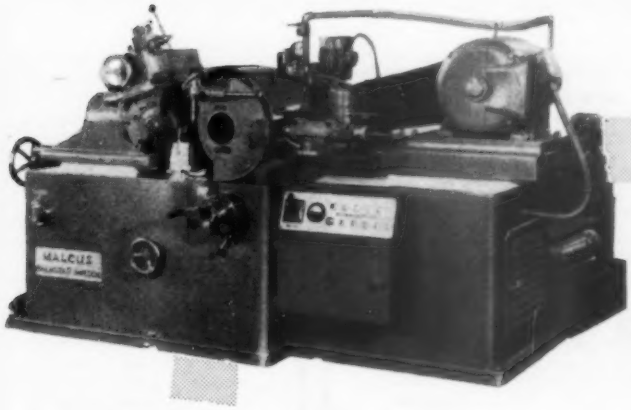

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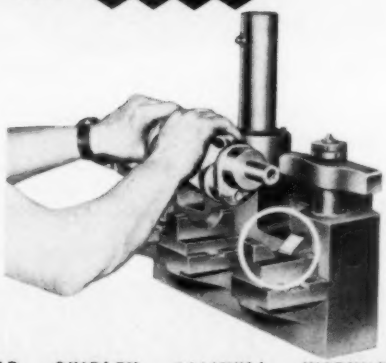

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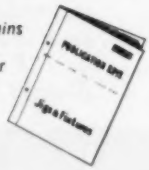

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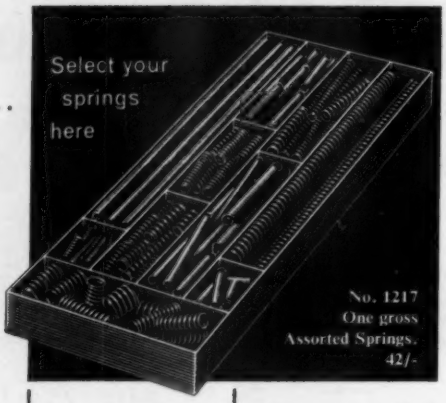

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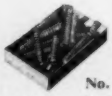

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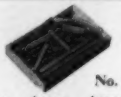

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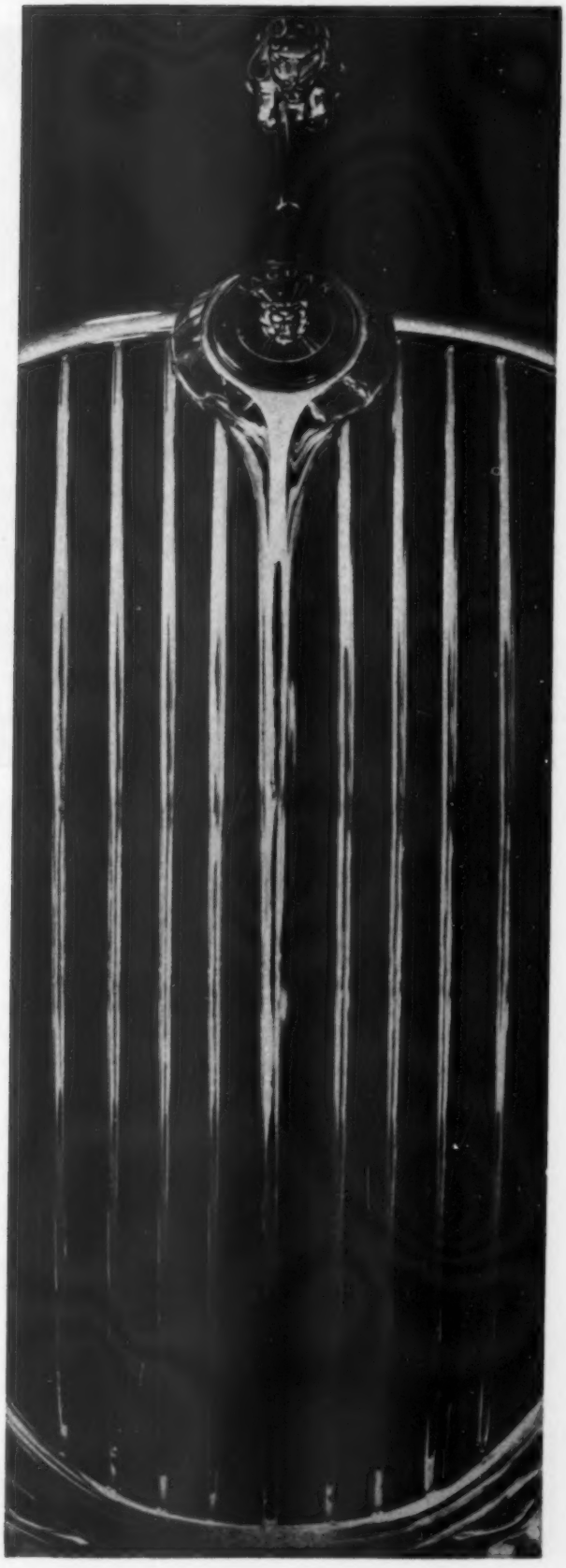

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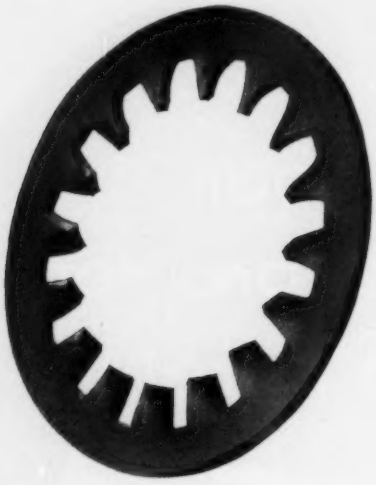

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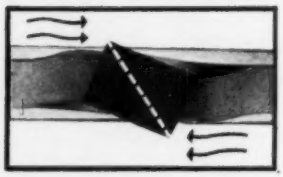

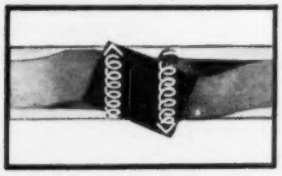

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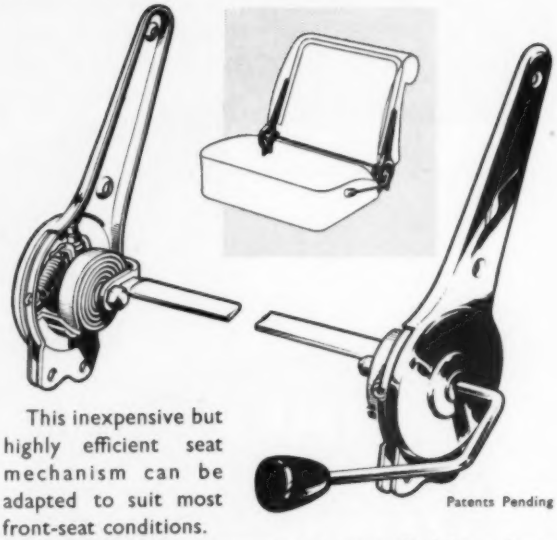

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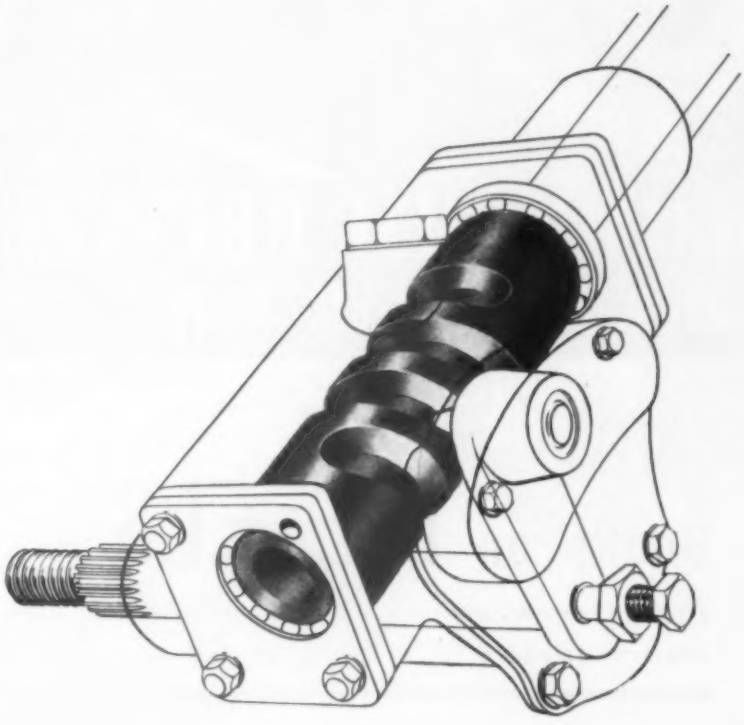

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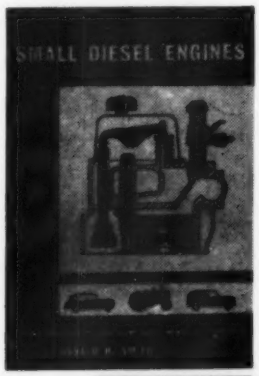

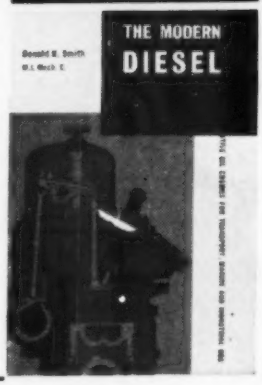

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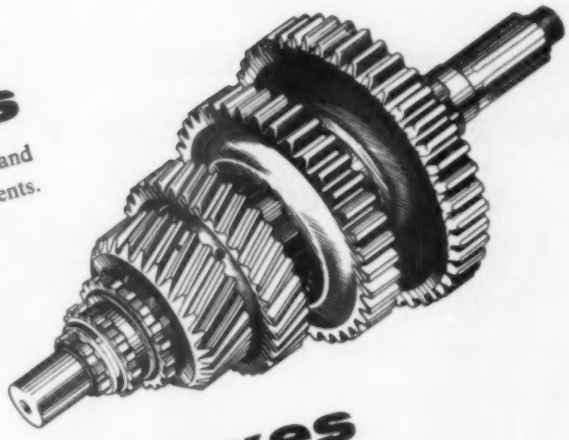

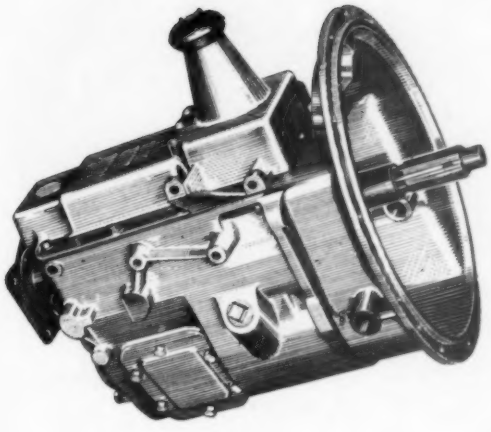

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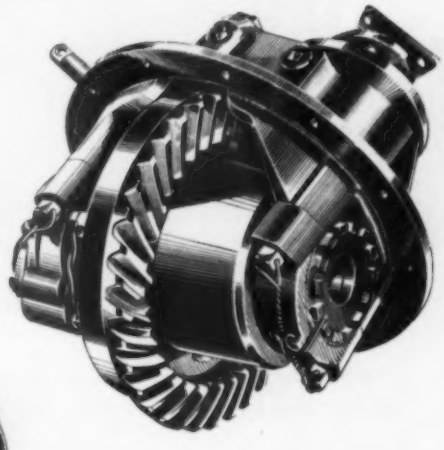

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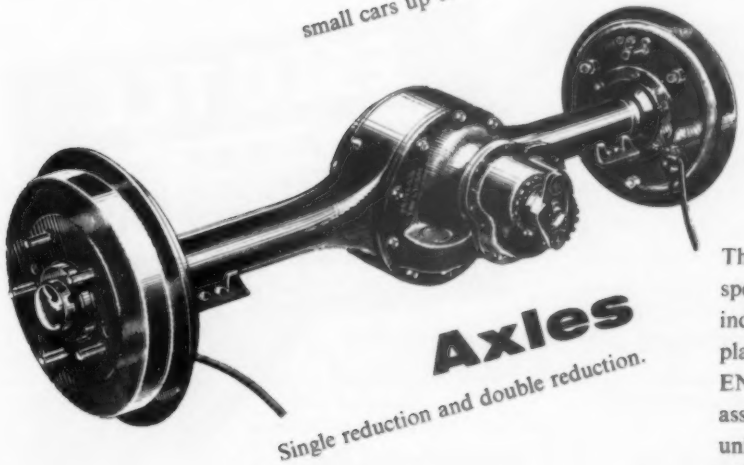

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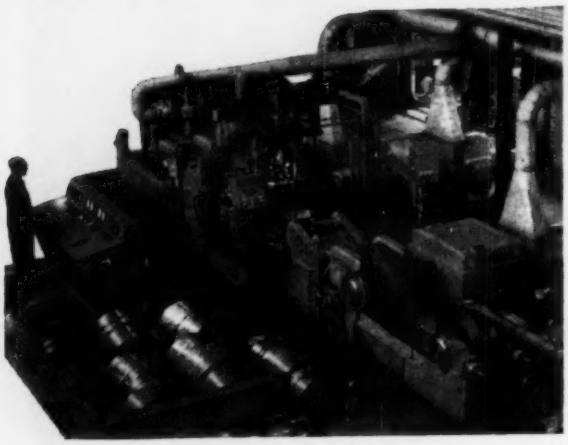

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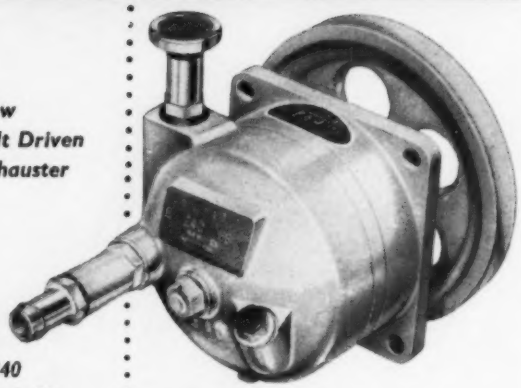

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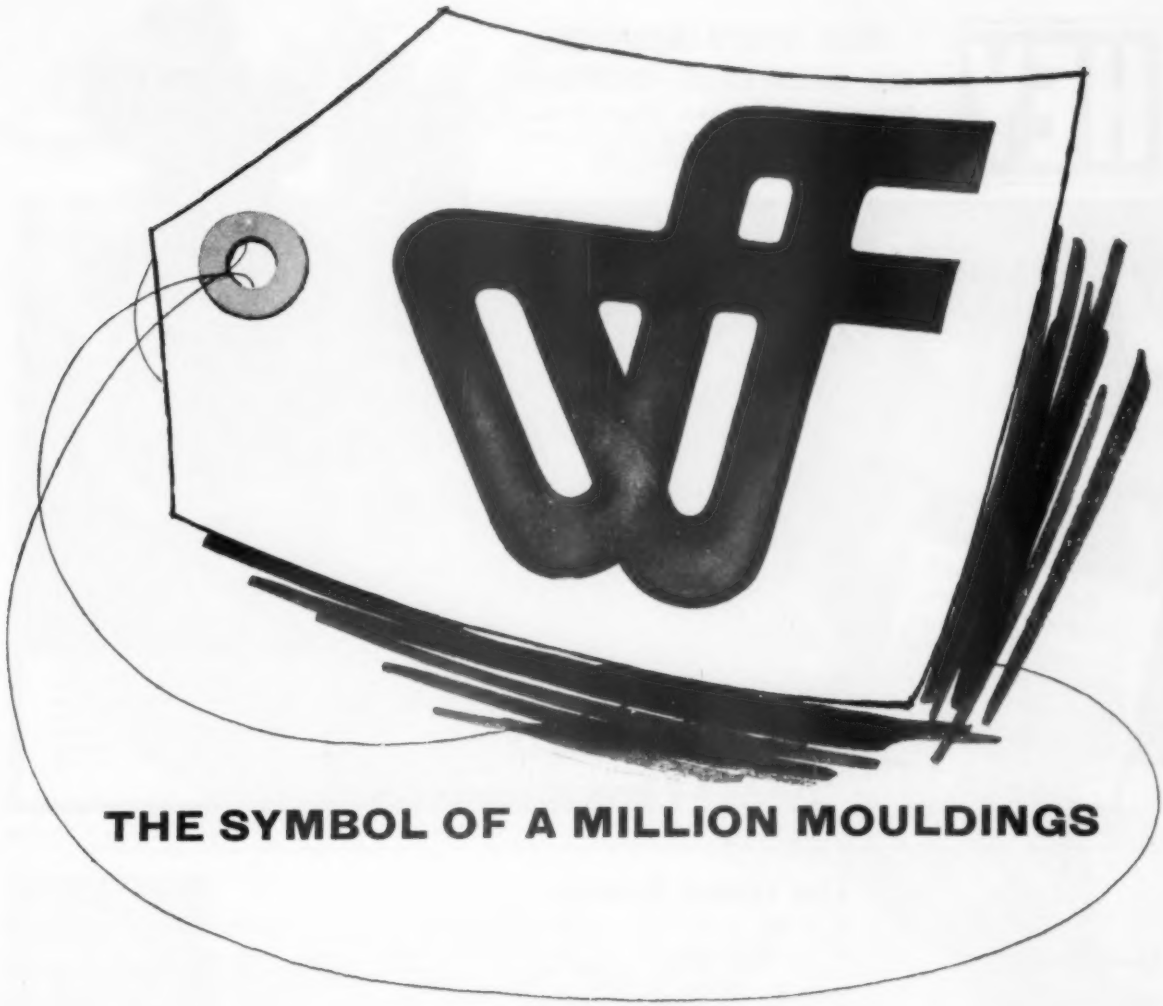

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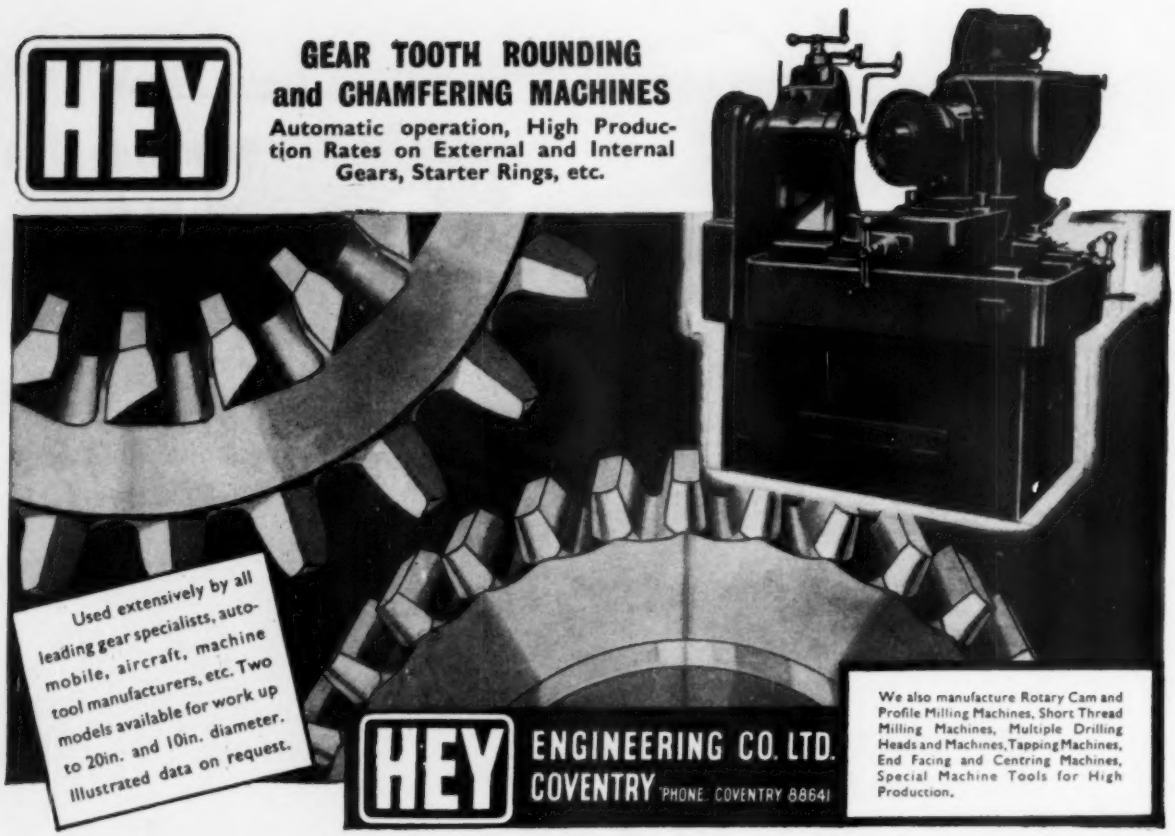

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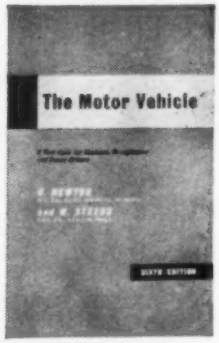

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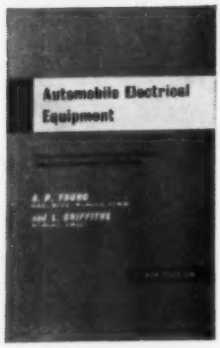

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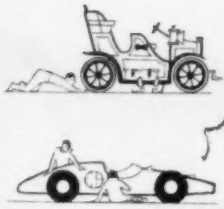

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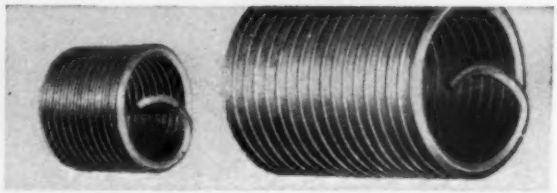

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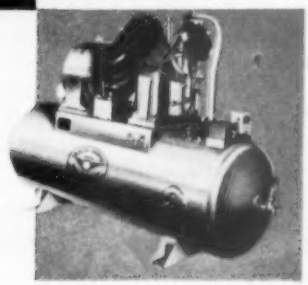

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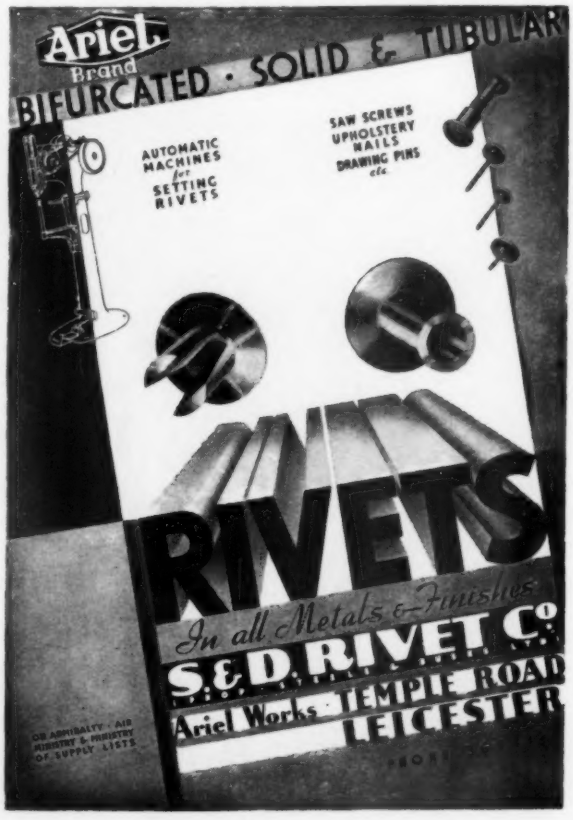

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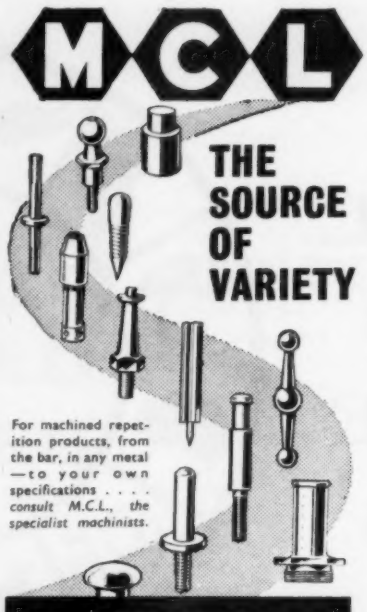

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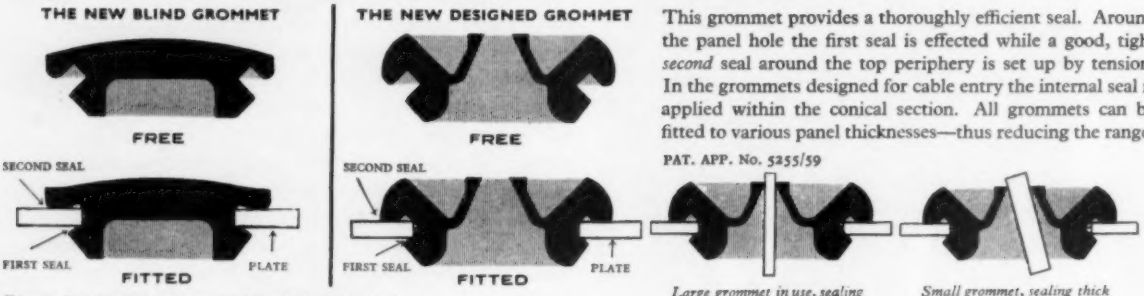

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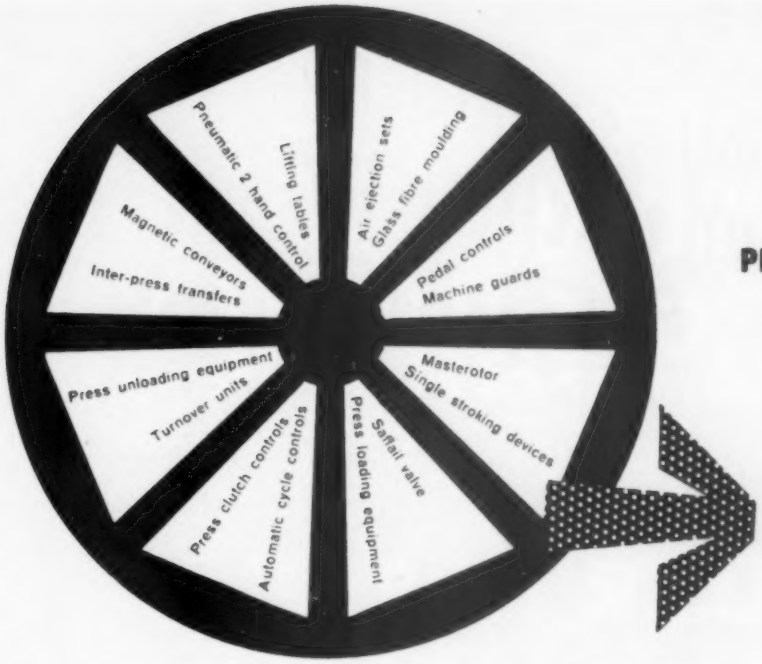

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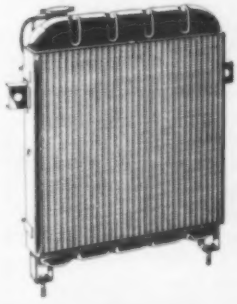

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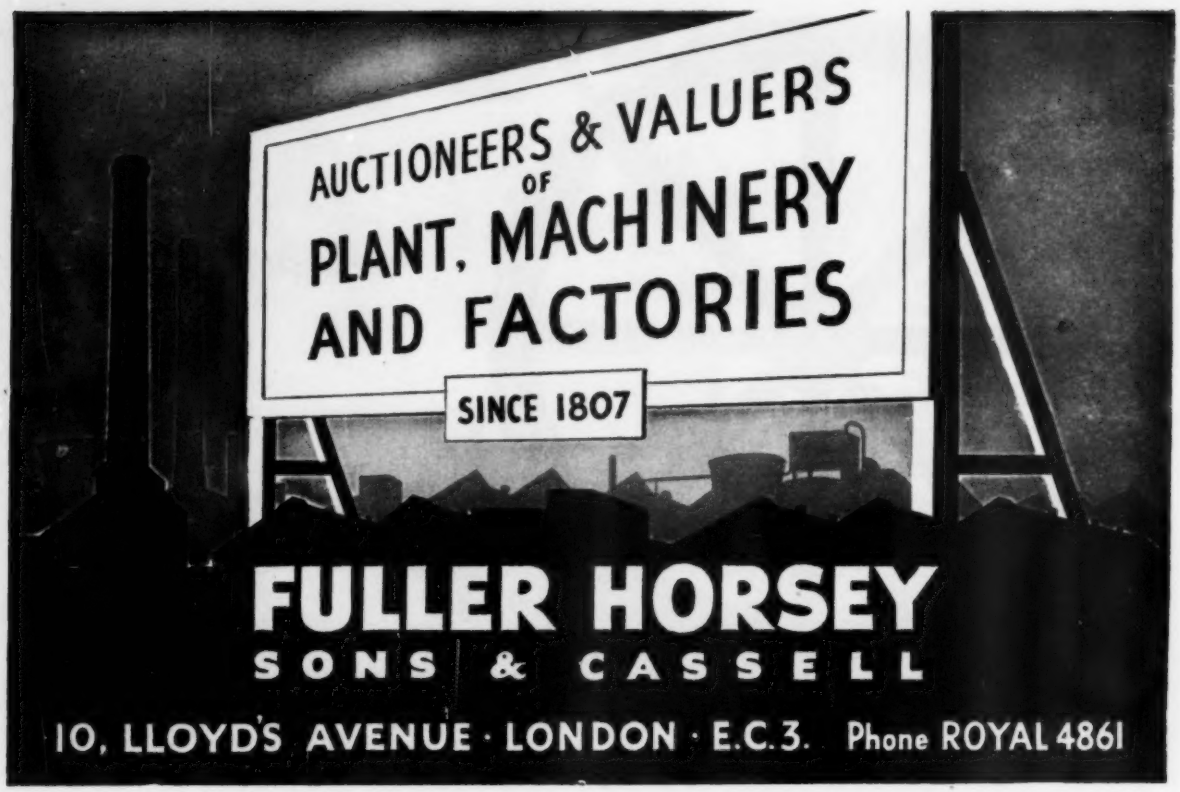

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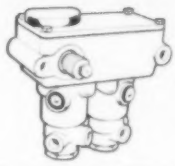

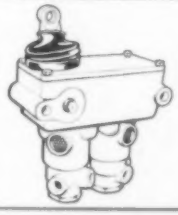

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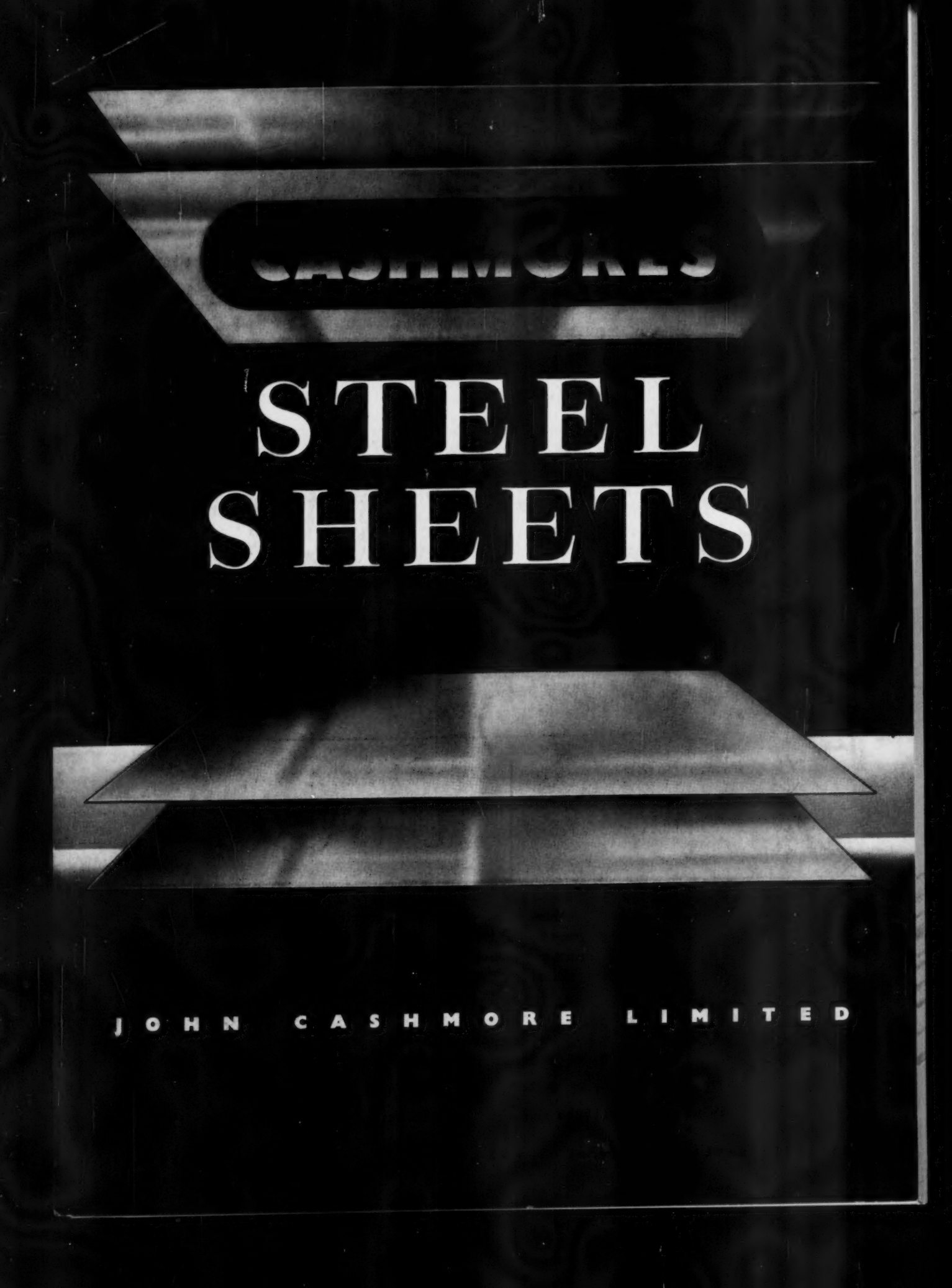
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